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A.M.A. ARCHIVES OF SURGERY

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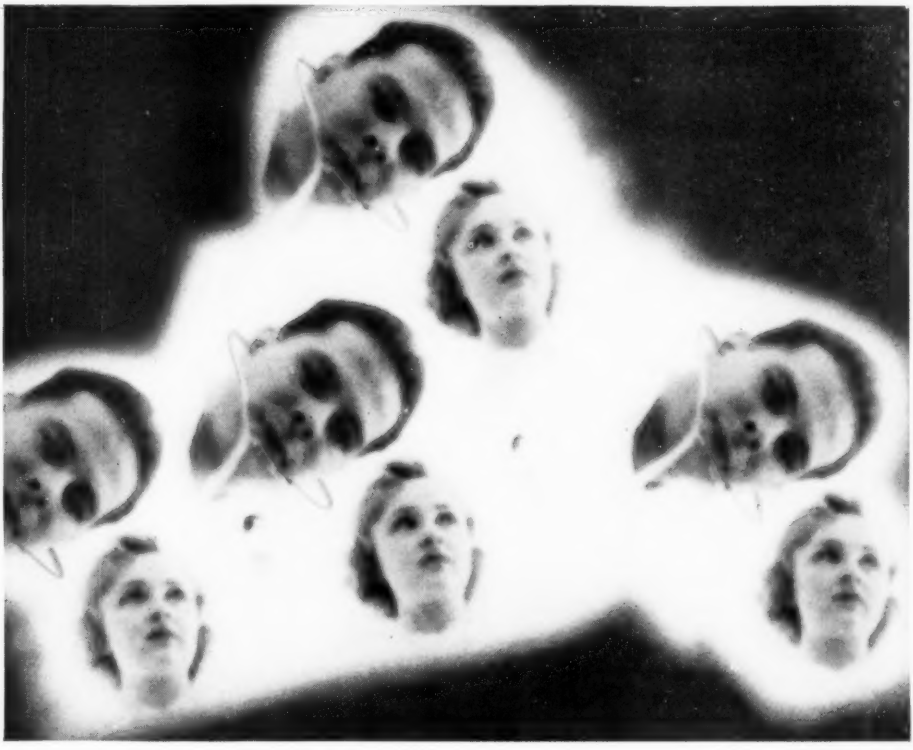

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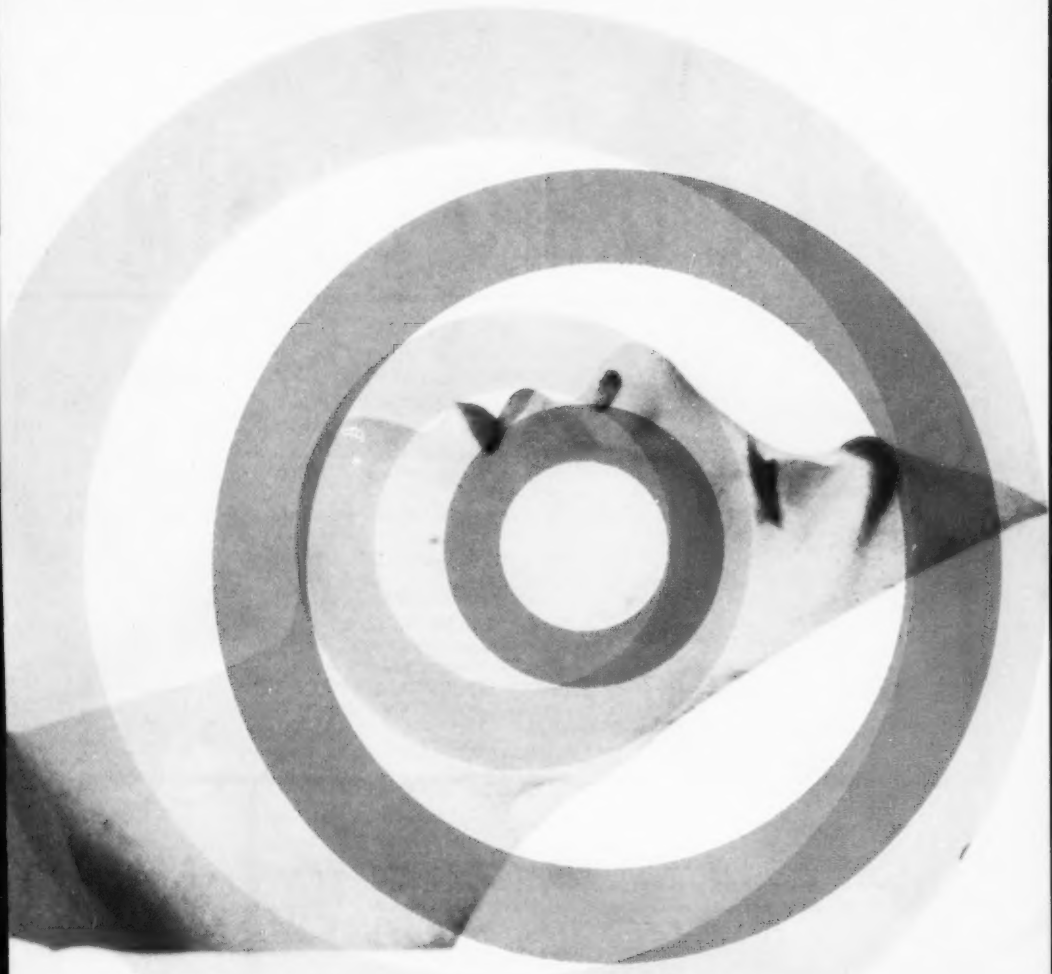

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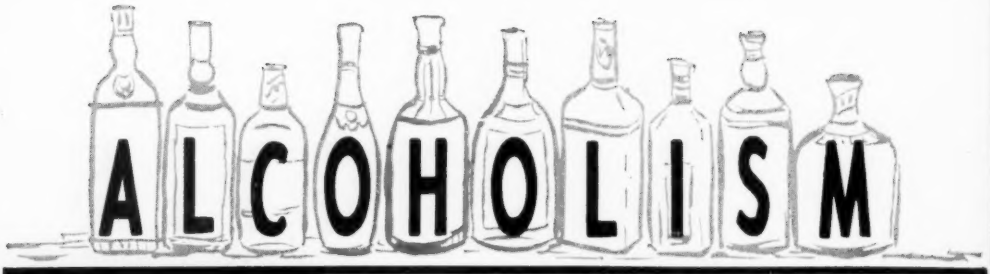

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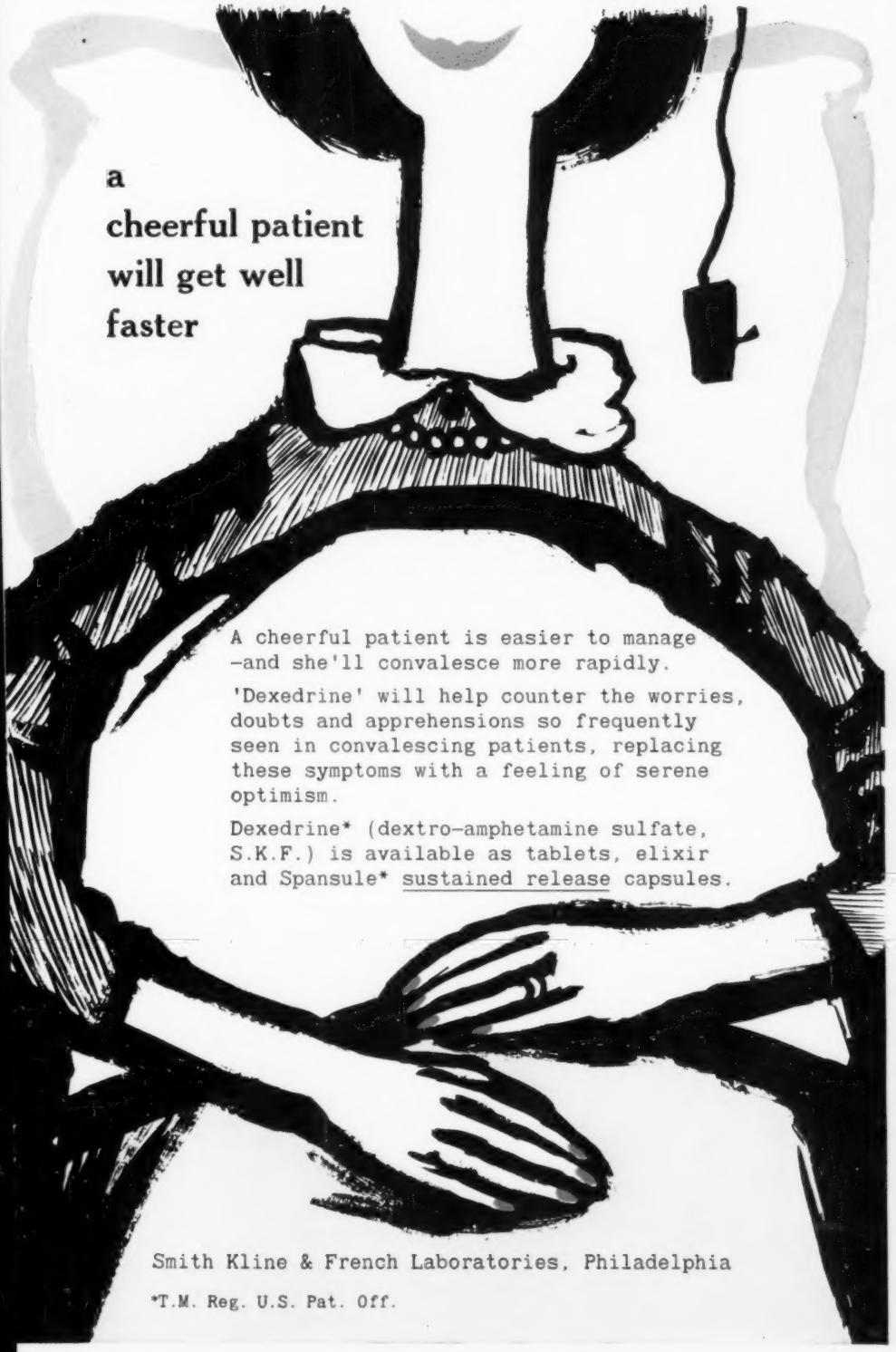

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Role of the Armed Forces Institute of Pathology in American Medicine

CAPT. WILLIAM M. SILLIPHANT (MC), U. S. N.

FOREWORD

An editorial entitled "Research, Investigation, and Teaching in the Armed Forces Medical Services," published in this journal,[1] called attention to the fine work being done in the hospitals and research centers of the Armed Forces, where facilities for research, clinical investigation, graduate training, and medical therapy are worth-while counterparts of civilian hospitals, clinical activities, and university teaching centers. In addition, the accomplishments of Dr. Frank B. Berry, Assistant Secretary of Defense (Health and Medical), with his distinguished group of medical consultants, and the members of the Panel on Medical Sciences of the Department of Defense, which is under the chairmanship of Dr. Richard Kern,* Professor Emeritus of the Department of Medicine, at Temple University School of Medicine, were mentioned. Both groups have been meeting at the various medical installations of the Armed Forces in this country, and the former group in other countries as well. The purpose of these groups is to observe the medical activities in the Armed Forces, both clinical and experimental. The latter group also has been acting as advisors to the Assistant Secretary of Defense for Research and Engineering.

The last meeting of the Panel on Medical Sciences was held at the Armed Forces Institute of Pathology in Washington, D. C. One-half day of the day-and-a-half meeting was given to administrative problems relative to the activities of the Panel and suggestions to be sent

* Members of the Panel on Medical Sciences of the Department of Defense are as follows:

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Secretary, Advisory Panel on
Medical Sciences

to the Assistant Secretary of Defense. In the afternoon orientation talks were given by members of the staff, and the following half-day was given to a report of sample research projects being carried out and a tour of the various departments of the Institute.

The address of the present Director (this position is alternated among the three branches of the Armed Forces at intervals) on the organization and management of the Armed Forces Institute of Pathology seemed of such general interest to all medical men and surgeons that I thought wide circulation should be given to it, and, at my request, Captain Silliphant has sent me his paper, which we are very happy to publish.

Mayo Clinic. WALTMAN WALTERS, M.D.
Rochester, Minn.

1. Walters, W.: Research, Investigation and Teaching in the Armed Forces Medical Services, Editorial, A. M. A. Arch. Surg. 74:200-201 (Feb.) 1957.

It is understood that most of the members of this Panel have only a vague knowledge of the mission and functions of the Armed Forces Institute of Pathology and of the role it plays in the over-all aspects of military and civilian medicine. With that as advance knowledge, these orientation remarks were formulated. To accomplish my objective more readily, I believe I should first touch briefly on the historical background of this Institution.

Historical Background

Perhaps sometime prior to the turn of the century, your parents or grandparents visited the old Army Medical Museum at 7th St. and Independence Ave. S. W., Washington. That would be true from wherever you came, as visitors from here and all over the world have wandered through its passageways for the past 96 years. It was established on May 21, 1862, and was the parent organization of the AFIP. It was set up to provide a laboratory in which pathologic material from disease, wounds, and injuries sustained in the Civil War could be utilized for research and the training of medical officers of the Army. Though vastly expanded, these basic objectives are still in effect.

For purposes of brevity, this span of 96 years can be readily divided into three rather distinct functional periods.

Submitted for publication April 10, 1958.

An orientation address before the Advisory Panel on Medical Sciences to the Secretary of Defense, March 28, 1958.

1. 1862-1920

This period covers roughly the first 60 years, to the end of World War I. During this time the main emphasis was on the Museum, with its collection of morbid anatomical specimens and historical medical instruments and equipment on display to the public. The collection of historical microscopes alone, numbering over 500, is said to be the best of its kind in the world. Some of the pathologic material collected on the Civil War battlefields is still on display today. There you may see hundreds of bones from that war, many depicting various stages in the healing of fractures, some with the missiles still embedded. Owing to modern methods of treatment, such specimens are no longer obtainable and are truly museum pieces. On display there, too, you may see specimens from the necropsy of President Lincoln, together with the bullet which killed him. Close by, you may study the bullet-pierced cervical spine of John Wilkes Booth, who shot him. Among other specimens from historical figures of days gone by, which would probably otherwise have been lost, are the shattered dorsal spine of President Garfield and slides of the cancer which killed President Grant.

2. 1920-1949

For approximately the 30 years following World War I there were certain evolutionary changes which led the Museum into more active participation in the study of living pathology. This was set in motion by two important steps taken in the early 20's.

A. Shortly after World War I the Museum was made the central laboratory of pathology for the Army, which meant that records and specimens from selected surgical cases and autopsies, performed at Army medical installations, were by regulation sent to the Museum for diagnostic review and permanent file. This was the beginning of the consultation service. These regulations have remained in force to the present time and now embrace the Navy and Air Force, and, by special arrangements, Veterans' Administration Hospitals and the Atomic Energy Commission.

B. The second step was accomplished by the establishment, over 30 years ago, of the American Registry of Pathology, now one of the four major professional departments of the AFIP. This Registry functions under the sponsorship and guidance of the National Research Council and receives the support of 17 national medical societies. By means of this, the Army Medical Museum became affiliated with, and established an official contact with, the civilian medical profession.

3. 1949—

On July 6, 1949, on recommendation of Hawley Board (Committee on Medical and Hospital Services of the Armed Forces) the Army Medical Museum became the Armed Forces Institute of Pathology (about four years earlier it had become the Army Institute of Pathology). It was proclaimed by its new charter to be a joint agency of the three military departments, under the authority, direction, and control of the Secretary of Defense, with the Secretary of the Army as the management control agent. The policy direction of broad administrative and professional matters is vested in the Board of Governors, which consists of the Surgeons General of the Army, Navy, and Air Force. The Director is to be a medical officer qualified in pathology and with administrative experience, selected from one of the armed services. The Directorship is normally to rotate every four years among the Army, Navy, and Air Force, in that order. A Senior pathologist from each of the services not represented by the Director is appointed as a Deputy Director.

In February, 1955, the transfer was made from the old red brick building, in the downtown area, to this new building. In May, 1955, President Eisenhower dedicated it, in the presence of about 4000 guests. In his dedication address, he concluded by saying: "I dedicate this building to the conquest of disease so that mankind, more safe and secure in body, may more surely advance to a widely shared prosperity and an enduring and just peace."

Relationship with Other Federal Agencies

In 1947, the Institute became, by special agreement between the Surgeon General of the Army and the head of the agency concerned, the central laboratory of pathology for the Veterans' Administration and the Atomic Energy Commission. About the same time, it was designated as a consulting laboratory for the U. S. Public Health Service. Consequently, the professional staff is highly integrated and is made up of doctors and scientists from the Army, Navy, Air Force, Veterans' Administration, U. S. Public Health Service, and Civil Service. It can truly be said that it makes no difference what uniform or clothes are worn here, or from what agency the individual members of the staff receive their pay, their objectives and loyalties are common and they all work harmoniously together.

The Threefold Mission

The threefold mission of the Institute has been long established. It can be stated briefly as Consultation, Education, and Research in pathology. Education and research was written in the original charter of 1862, and, as I noted earlier, consultation for the individual patient was added about 35 years ago. These basic functions still apply, though with changing emphasis. The new laboratories were planned for the prac-

tice of progressive pathology, so that consultation can now be supported by the most advanced laboratory procedures. With modern equipment the staff is now able, through various approaches, to explore the basic structures and functions of the cell. Experimental pathology is now possible, the entire top floor being devoted to animal holdings and experimental surgery.

On July 1, 1955, Dr. Ernest W. Goodpasture began his work as Scientific Director. His primary job was to help organize and establish programs for the new laboratory facilities. This was not an easy task, particularly as qualified scientists and supporting staff were not easily or rapidly acquired. With patience and perseverance, however, and with a gradual increase in staff personnel, the research program has been accelerating rapidly, though we are still far below our research potential. To extend research much further additional billets will be needed.

As this is a Department of Defense activity supported by Army funds, our operational work and research must in general support military needs. Of over 100 research projects currently underway, most are of prime importance to military medicine. Among such current projects in our laboratories which I will particularly mention here are these:

1. Aviation pathology—a new field now expanding into pathologic aspects of space medicine.

2. Fluorescent antibody project, one of considerable military importance, and having a great potential in the rapid diagnosis and pathogenesis of acute infectious diseases.

3. Radiation preservation of foods program—effects of irradiated foods on experimental animals. The AFIP supports pathology-wise this large Army project.

4. Pathology of ionizing radiation. These studies are based on experimental investigation, as well as on the pathologic material received at the AFIP from the Atomic Bomb Casualty Commission on the survivors of Hiroshima and Nagasaki.

5. Coronary arteriosclerosis and myocardial damage in young adults of military age. This is an important military problem.

6. Pathology support for accleration and deceleration experiments by the Navy and Air Force. AFIP pathologists take part in the field experiments and perform "on the spot" pathology studies on the experimental animals.

7. Pathology support rendered in experimental studies on rats explosively decompressed at a simulated height of 65,000 ft. This was in cooperation with the Aircrew Equipment Laboratory, Naval Air Station, Philadelphia. It was the first time that a study of the effects of pure explosive decompression was ever accomplished. This was reported in the *Journal of Aviation Medicine* of January, 1958.

8. Incidence of leukemia in children following prenatal x-ray pelvimetry of the mother. This is a controversial issue at the present time. Some recent articles in the foreign literature lend some credence to the possibilities of an increased incidence of leukemia among such children. The contacts of the AFIP with civilian pediatric clinics render a study of several thousand cases quite feasible.

Liaison with Civilian Medicine

Despite the military orientation of the work of the AFIP, however, no other military activity maintains such close liaison with civilian medicine. This is possible by virtue of the American Registry of Pathology, which was mentioned earlier. By virtue of the Registry, civilian pathologists are authorized to send pathologic specimens to the Institute for registration and file. In return for the specimen they are privileged to request a consultation on the case. This results in a two-way benefit. The contributor is rendered a consultation, and the specimens provide an excellent source of well-documented material, which helps build up the Registry files for teaching and re-

search. A military activity may be considered fortunate to be able to collect good teaching and research cases from civilian pathologists for the "price" of a consultation. The consultations themselves constitute part of the intramural teaching program. From this large collection over the years, from both military and civilian sources, there has been published in the medical literature a wealth of articles on a great variety of subjects.

The educational program supports fully the military services, as does the consultation function. Education for the civilian is on a space-available basis, which permits a reasonable number of civilians to spend varying periods of time studying at the Institute. These persons sponsored through various sources, such as their home institutions, national medical societies, National Institutes of Health, and foundations, such as the Rockefeller, Damon Runyon, and W. K. Kellogg Foundations, and International Cooperation Administration. A few are self-supporting. These fellows and students represent almost all medical and surgical specialties, as well as pathology. They come here to study the pathology of their particular specialty. While here they receive credit from the several American Specialty Boards, for periods up to one year. In 1957 among the number of trainees in attendance here were 29 from 17 foreign countries.

Organization

As may be seen on an abbreviated organization chart (Fig. 1), the AFIP is organized into four major professional departments.

1. *The Department of Pathology.*—This is the heart of the Institute, to which approximately two-thirds of the staff personnel are assigned. This department carries on the consultation service, and here, too, most of the teaching and research work is done.

2. *The American Registry of Pathology.* It consists of 23 individual registries, each sponsored by one or more national medical, dental, or veterinary societies. Each registry is headed by a registrar, who is a senior member of the Institute staff. The Registry is responsible, among other things, for the production of teaching aids in the form of microslide sets, material for clinicopathologic conferences, brochures, and at-

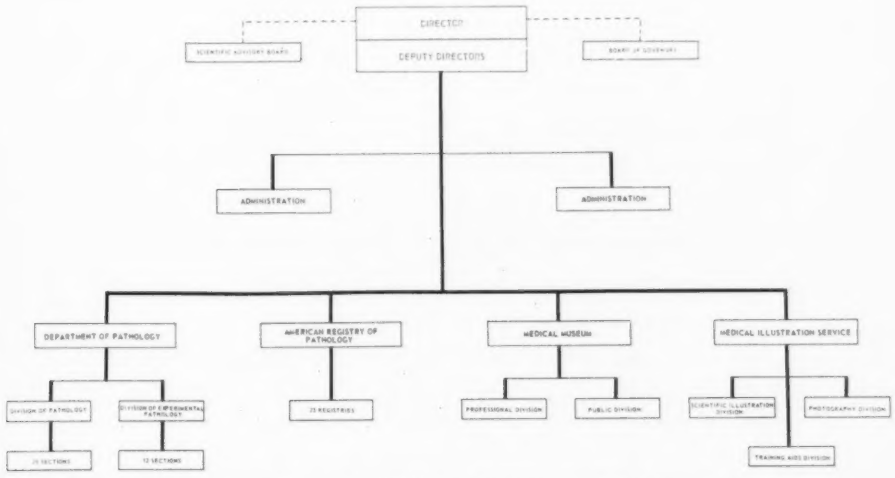

Fig. 1.—Organizational chart, Armed Forces Institute of Pathology. From the Armed Forces Institute of Pathology, Walter Reed Army Medical Center; Picture No. 56-21727-1.

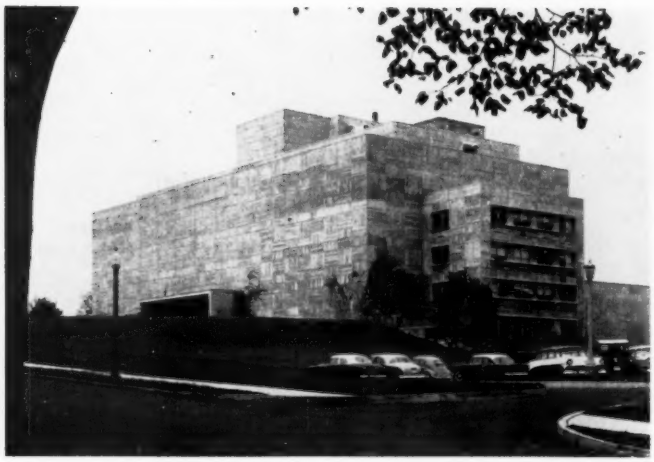

Fig. 2.—Armed Forces Institute of Pathology. From the Armed Forces Institute of Pathology, Walter Reed Army Medical Center; Picture No. 56 21727.

lases. More than 5000 loan sets were distributed last year.

3. *The Medical Museum.*—It consists of the public museum on the downtown site and the professional museum in the main building. The museum is dedicated to the collection and preservation of medical material of historic and scientific value, and its use for professional and public education.

4. *The Medical Illustration Service.*—This department supports the educational program of the AFIP and the Armed Forces Medical Services. Medical drawings, photographs, films, exhibits, and training aids are prepared in support of these programs. Here, too, the "Atlas of Tumor Pathology" is printed.

The new building (Fig. 2) consists of eight stories, three of which are underground. There being no windows, the building is fully air-conditioned. Its high-intensity lighting and changing pastel colors on the passageway walls militate against claustrophobia of the occupants. The building was constructed on the flexible module plan,

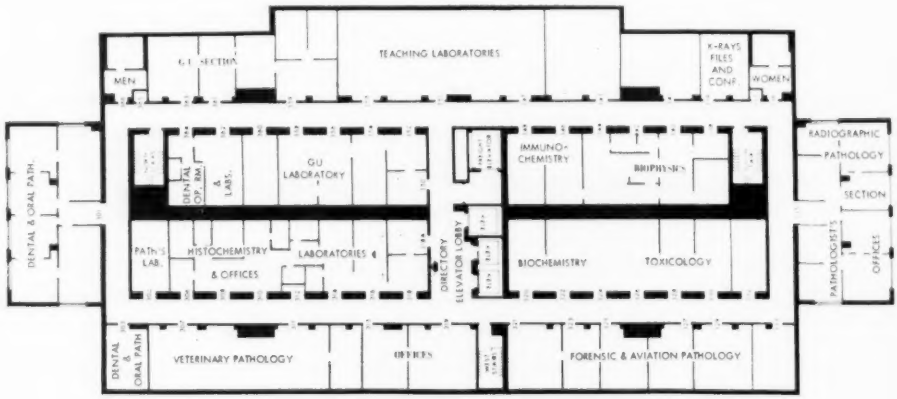

Fig. 3.—Armed Forces Institute of Pathology, third floor plan. From the Armed Forces Institute of Pathology, Walter Reed Army Medical Center, Picture No. 58-2917-24.

with demountable laboratory partitions, permitting at any time either single or multiple modules to be utilized as a single laboratory unit. The laboratories occupy a rectangular block centrally in the building. They lie back to back, separated by a 3-ft.-wide utility service core. A passageway encircles the laboratory block, peripheral to which are the various offices, teaching laboratories, and conference rooms. Two small wings jut from either end of the building, the site for future wing expansion (Fig. 3).

Relationship with Walter Reed Army Medical Center

Within this building is housed the Anatomic Pathology Laboratory of the Walter Reed Army Hospital, which is staffed by its own hospital pathologists. This was a 1950 Bureau of Budget decision to provide the hospital needed laboratory space. A pneumatic tube connects this laboratory with the Walter Reed Army Hospital operating rooms. Through it, surgical specimens are whisked to the laboratory, a distance of four blocks, within 30 seconds. Television facilities are being installed, by which the surgeon in the operating room can see, projected on a large screen within his vision, the frozen section, as simultaneously viewed by the pathologist. At the same time, the pathologist can observe the operative field on his own television receiver and can engage in a two-way conversation with the surgeon.

Also housed here is the main studio of WRAMC-TV. This is a compatible closed-circuit color television system, involving all Center activities. From here, programs can be transmitted by telephone wire to any point in the United States, and several have been. At the present time, microwave antennae are being installed on the AFIP roof, to beam programs by direct transmission to several local medical centers. These are the saucer-like objects you may have seen on approaching the building. Reception antennae are likewise being installed in order to pick up programs originating in local medical institutions. A two-way exchange has been in operation between the AFIP and the National Naval Medical Center and National Institutes of Health, in Bethesda, for some time. This WRAMC-TV is the largest medical color TV system in this country. It is fast assuming a laudable role in postgraduate medical education.

Logistic support to the Institute, including such items as heat, water, electricity, telephone, and janitor service, is provided by the Walter Reed Army Medical Center, on the grounds of which the AFIP building stands.

Recent Accomplishments

I would like now to mention some highlights of AFIP accomplishments, in the immediate past.

1. Toxoplasmic chorioretinitis: the demonstration by the Registry of Ophthalmic Pathology, in reviewing granulomatous lesions of the eye, that many cases of chorioretinitis, formerly diagnosed as tuberculosis or of unknown etiology, were due to Toxoplasma gondii, a protozoan parasite. This disease of adults is now recognized as a definite entity. Sixty cases are on file in the Eye Registry, a number which is four times that of any other single proved granulomatous chorioretinitis entity. Those cases positively diagnosed as tuberculous number only 15.

2. The demonstration of a formerly unrecognized liver disease now called "chronic idiopathic jaundice." It is thought to be an inborn error of metabolism with a familial tendency. The recognition of this disorder was of more than academic interest, for in many cases the disease had been diagnosed as chronic hepatitis or other liver disorder and given a poor prognosis. A few patients had had symptoms for over 50 years. Some had been subjected to laparotomy. With an awareness of this syndrome for which surgery is unnecessary, and the prognosis good, these patients may now be spared useless surgery and lead normal lives. A biopsy of the liver, with

needle or otherwise, is necessary for diagnosis. Twelve cases were originally segregated and reported by two AFIP pathologists, from a survey of 5000 cases of needle biopsy of the liver. About 70 additional cases of this disease have since been reported in the world's literature.

3. The demonstration of what is tentatively designated "pulmonary alveolar proteinosis," a new disease of the lungs of unknown etiology, recognized and defined as a new entity on the basis of the histopathologic study of 27 cases, 16 from the AFIP, 7 from Yale University School of Medicine and 4 from the Massachusetts General Hospital and Harvard Medical School. It is characterized by (1) the accumulation of a granular and floccular, PAS-positive, proteinaceous material, rich in lipids, in the alveoli, with little or no associated inflammatory reaction; (2) a chronic, but variable clinical course, with dyspnea and cough as the main symptoms, and (3) bilateral radiographic changes simulating severe pulmonary edema but persisting for months or years, sometimes with partial clearing or with progression. Five patients have shown improvement, and there have been eight deaths. The disease resembles pneumocystis pneumonitis in some respects, but differs from it in the absence of the organism and other major respects. A paper on this disease under joint authorship will appear soon in the *New England Journal of Medicine*.

4. The improved histopathologic diagnosis of fungus infections, particularly histoplasmosis, as a result of the use of improved special staining techniques, especially the Gomori-Grocott methenamine-silver nitrate method. Of 134 undiagnosed pulmonary granulomas submitted to the AFIP in one year, a specific etiologic agent was demonstrated in approximately 60%, and of the latter approximately 70% were histoplasmosis.

These discoveries are a by-product of continuing morphologic observations, indicating that anatomic pathology is far from a dead subject.

Even though no patients are under treatment at the AFIP, the dissemination of such information naturally results in better patient care. Last year this was accomplished through the publication in the medical literature by the staff of two books, five chapters in books, and 43 articles. From all indications, publications for this year may be almost double that of last year.

Awards and Honors to Members of AFIP Staff in Past Year

1. Col. Joe M. Blumberg, (MC) U. S. Army, Deputy Director, was elected vice-president of the American Society of Clinical Pathologists. He is the first military medical officer ever to attain such a high office in that society.

2. Capt. W. W. Ayres (MC), U. S. Navy, Assistant Chief, Pathology Division, awarded the Sir Henry Wellcome Scroll, Silver Medal, and $500 cash award for the publication of the best paper in the *Military Surgeon* for 1957. This paper was based on AFIP file material and was entitled, "Tumors of the Cauda Equina."

3. Col. Joseph L. Bernier (DC), U. S. Army, Chief, Dental and Oral Branch, was elected president of the American Academy of Periodontology for 1958.

4. Col. Carl F. Tessmer (MC), U. S. Army, Chief of the Radiation Injury Section, was elected president of the Washington Society of Pathologists for 1958.

5. Major Daniel A. Collins, U. S. Army, a dental pathologist, was named "Man of the Decade" by his alma mater, Payne College, Ga.

Before closing, I would like to quote short portions from some unsolicited letters which I receive from time to time in my position as Director. It is understood that whatever credit is reflected in these letters belongs to the staff as a whole. These quotations and their diverse sources will, I believe, indicate to you that the results of

our work at the AFIP are felt far and wide, both in military and in civilian medicine.

1. From a civilian pathologist: "I would know of no other place in the world where a man could get more comprehensive advice, more freely and more kindly rendered, than at the AFIP."

2. From a service pathologist: "We are most grateful for the consultation service provided by the AFIP. Let me assure you that I have tried to impress the doctors here how much we are benefited from this consultation service, which is truly unique in the world."

3. From a leading medical school: "The Institute has done so much for pathology in this country that one always thinks of it first when there is another possible role of usefulness for it."

4. From a Major General of the U. S. A. F. (a nonmedical officer): "I have been sincerely impressed by the wholehearted cooperation you and your associates have demonstrated in the support of our accident-prevention effort. The AFIP has been outstanding in its effort to achieve a comprehensive program for pathologic inquiry into the cause and effect of aircraft accidents."

5. From a Major General, the Deputy Director of the British Army Medical Service, after a day at the AFIP: "I had heard so much of the work of the Armed Forces Institute of Pathology that I expected a lot, but the reality completely exceeded my expectations."

Conclusion

Owing to the limited time at my disposal, this paper of necessity has been only a bird's-eye view of the AFIP, from the time it arose as a collection depot of human parts from the battlefields of the Civil War, to its vastly expanded horizons in the newer concept of pathology today.

In this age of advanced technology, leading inevitably to man's venture into outer space, a challenge of unlimited magnitude faces those who labor within these walls. As it has fulfilled its role as a leader in the field of pathology and military medicine in the past, the AFIP looks to a future of even greater achievements in the years ahead.

Armed Forces Institute of Pathology, 6825 16th St., N. W. (25).

Intra-Abdominal Hemorrhage Following Abdominal Surgery

GEORGE E. MOORE, M.D., Ph.D., and MEREDITH J. PAYNE, M.D., Buffalo

The occurrence of sudden intra-abdominal hemorrhage several days after surgery is distressing and puzzling. In this report, the case histories of three patients are used to indicate a set of circumstances which may produce late postoperative hemorrhage from the hepatic artery, from other branches of the celiac axis, or at the site of ligation of branches of other large intra-abdominal arteries. Subsequent discussion will indicate the belief that the fundamental cause of these instances of arterial rupture is arteritis. Evidence of features common to the delayed hemorrhage from war wounds adjacent to large vessels of the extremities and from carotid arteries subsequent to neck dissections will be pointed out.

The recognition of this complication is important, since accurate identification of the site of hemorrhage and its control may be life-saving.

Report of Cases

CASE 1.—A 77-year-old white woman was seen at Roswell Park Memorial Institute in April, 1954, with a large mass in the upper right abdominal quadrant. Five years previously the patient had had a resection of the right colon for a carcinoma of the cecum. The present lesion was considered to be either a second primary or a solitary metastasis. A radical resection of the tumor was accomplished, which originated from nodes adjacent to the midcolic artery and which extended to the pancreas and duodenum. The patient's postoperative course was marred by bouts of elevated temperature. Sixteen days following the primary operation, a reexploration was done, and an abscess cavity situated at the site of a pancreaticojejunostomy was drained. At the time of operation, it was observed that recent intraperitoneal bleeding had apparently taken place, as evidenced by several large clots. The source of bleeding was thought to be at the base of the mesocolon, which formed a portion of the wall of the abscess cavity. A Penrose drain was inserted into the abscess cavity. Postoperatively about 500 cc. of blood and serous fluid continued to exude daily along the drain. Because of this persistent bleeding, her abdomen was again explored. The source of bleeding was identified as the ligated stump of the gastroduodenal artery. The hepatic artery and adjacent tissues were included in the wall of the abscess cavity previously mentioned. The actual rent was in the hepatic artery itself immediately adjacent to the silk tie which was still in place on the gastroduodenal artery (Figure). The defect was closed with continuous sutures of 000000 arterial silk.

After this third operation, the surgical wound failed to heal for several weeks. The patient's recovery was further complicated by the development of an intestinal-vaginal fistula subsequent to a previous attempt to drain a presumed pelvic abscess. The patient died in four months, without being discharged from the hospital.

Postmortem examination revealed the site of repair of the hepatic artery to be well healed, with an adequate lumen. No residual tumor was apparent.

CASE 2.—A thin 71-year-old man was admitted to the hospital after the discovery of a large mass in the upper midepigastrium. The patient had had a partial gastrectomy for carcinoma of the stomach five years previously.

At operation, a solitary metastasis arising from a suprapancreatic lymph node was found. An extensive dissection involving the gallbladder, liver, pancreas, and mesocolon was necessary to ensure removal of the metastasis.

The patient's postoperative course was complicated by copious bile-stained fluid from a drain inserted in the liver bed. It was noted that wound healing was impaired. Seven days postoperatively, there was a sudden hemorrhage of approximately 500 cc. through the lateral aspect of the wound. Two days later several separate episodes of frank arterial bleeding occurred.

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Departments of Surgery, Roswell Park Memorial Institute.

The patient was taken to the operating room, and several large blood clots were removed. No single bleeding site was found. However, as a result of our previous experience, tissues overlying the hepatic artery were carefully exposed by gentle dissection; an immediate spurt of blood resulted. Digital compression of the hepatic artery controlled the bleeding, and inspection revealed a ragged 3 mm. rent in the hepatic artery at the base of the gastroduodenal artery, which had been ligated with a single tie of 000 silk. The ligature was still in place, but the artery was discolored and seminecrotic. An attempt was made to close the arterial defect with a continuous 000000 suture, even though it was realized that the arterial wall was abnormal.

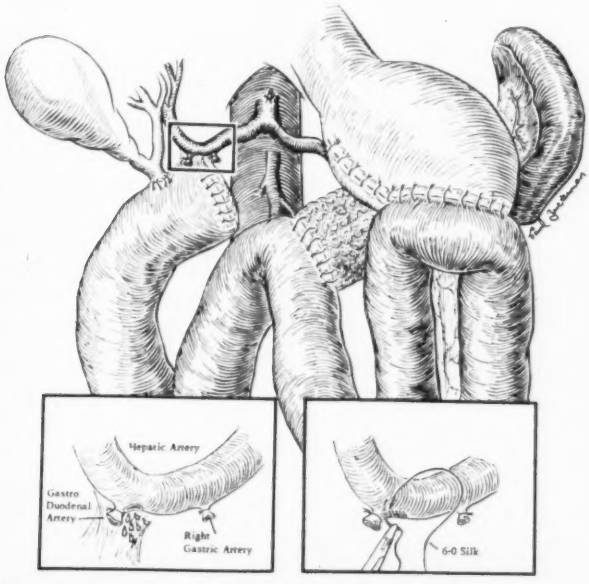
Three days later, the patient again had a massive hemorrhage, and reexploration revealed the bleeding to be from the same site. Since the artery was seminecrotic, further repair or resection with reanastomosis was not attempted. The hepatic artery was ligated just proximal to its division into the right and left hepatic branches. The patient recovered from this operative procedure uneventfully except for delayed healing of the operative wound. Sections of the hepatic artery revealed an arteritis involving all of its layers. A battery of liver tests performed prior to his discharge from the hospital were essentially normal.

The patient's general condition failed to improve, necessitating readmission to the hospital two months after his last operation. Shortly afterward the patient died of malnutrition and bronchopneumonia. Postmortem examination revealed the ligature of the proximal segment of the hepatic artery to be in place. The posterior portion of the right lobe of the liver contained a 10 cm. cystic area of necrosis; the remainder of the liver had a normal architecture.

CASE 3.—The patient had a radical gastropancreatoduodenectomy and partial resection of the transverse colon for carcinoma of the pancreas. A slight hemorrhage along the Penrose drain in the right flank ensued on the fourth postoperative day. The patient was treated with multiple transfusions. On the following day the bleeding increased and appeared to be from an arterial source. Laparotomy revealed a small abscess cavity in juxtaposition to the pancreaticojejunal anastomosis. The site of hemorrhage was identified as adjacent to the ligated stump of the gastroduodenal artery. Brisk hemorrhage from this site was controlled by digital compression, and the opening in the hepatic artery was closed with continuous 000000 silk suture without compromising the lumen (Figure).

The patient's subsequent postoperative course was uneventful.

Additional Cases.—In addition to the three cases reported above, two similar instances were encountered in a review of the major surgery performed in two institutions over a 10-year period. One patient hemorrhaged from the celiac axis at the base of a ligated stump of the splenic artery three weeks postoperatively. It is noteworthy that one week previously the patient had a drainage



Delayed postoperative hemorrhage from the hepatic artery at the base of the ligated gastroduodenal artery, associated with an abdominal abscess (Cases 1 and 3).

of a subphrenic abscess. An attempt to repair the defect was unsuccessful.

A fifth case of an intra-abdominal hemorrhage occurred in a patient subsequent to performance of a radical gastrectomy. This case also had the common features of extensive malignancy, malnutrition, and impaired wound healing. The site of the arterial rupture was the hepatic artery, which was successfully repaired without compromising the lumen.

Comment

The common elements associated with massive postoperative bleeding described above are (1) major surgery in a debilitated patient (with malignancy), (2) evidence of impaired wound healing, (3) intra-abdominal infection, (4) a biliary or pancreatic fistula, (5) severance and ligation of a major branch of the hepatic artery or other component of the celiac axis, and (6) hemorrhage, usually occurring late in the postoperative period.

One can envision several technical failures as contributing to the catastrophe described: (1) fine suture material, which was tied too tightly; (2) injury of the vessel wall in an atempt to leave only a short stump of the arterial branch being ligated; (3) injury to the arterial wall during the placement of a suture ligature.

In the reported cases, all of the ligatures were single or double ties of 000 silk. That there was not direct involvement of a single surgeon in more than one case seems to obviate the importance of a personal factor. In our opinion, the most important elements were the presence of a failure of healing as a result of malnutrition and the presence of infection or bile or pancreatic juice at the site or arterial ligation.

The similarity of these cases to those seen during World War II was called to our attention by Prof. John R. Paine. A good review of the development of arteritis with secondary hemorrhage of major arteries was detailed by Bailey.[1] It was noted that secondary hemorrhage was commonest in infected wounds and that, as in the cases reported in this paper, secondary hemorrhage generally occurred as two separate episodes, the first a small initial hemorrhage or discharge of clot, and the second a major hemorrhage two or three days later. The treatment of choice was described as ligation of the vessel; however, recent advances in vascular surgery might modify this opinion.

Hemorrhage from the carotid arteries associated with complications of radical neck dissection is well known to head and neck surgeons. In general, this misfortune does not occur unless the wound flaps have remained unhealed, a fistula has developed below the wound flap, or an abscess has developed immediately adjacent to the artery.

Summary

Five cases are reviewed in which massive postoperative bleeding occurred from a rent of the hepatic artery at the base of a ligated stump of the gastroduodenal artery or from other major elements of the celiac axis at the site of ligation of its branches. Clinical examination and later histological confirmation of the presence of local arteritis were noted. Successful repair of such a bleeding site is dependent upon accurate exposure of the artery and a minimal amount of surrounding arteritis, allowing suture of the rent with fine arterial silk. In the presence of severe arteritis and degeneration of the artery, it is recommended that distal and proximal ligation be consummated. An arterial graft might be considered in the treatment of similar injuries of large vessels.

This sort of arterial bleeding is compared with secondary hemorrhage occurring in association with war injuries and with the postoperative rupture of the carotid arteries associated with complications attendant on neck dissection.

666 Elm St. (3).

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Massive Thyroid Hemorrhage Producing Acute Respiratory Obstruction

JAMES J. BERENS, M.D., and ROBERT F. EASELEY, Phoenix, Ariz.

Hemorrhage into thyroid adenomas is relatively common but usually does not attain clinical significance. Small hemorrhages and the secondary results of hemorrhages, such as necrosis or cystic degeneration in thyroid nodules, are frequently seen by pathologists on gross or microscopic examination. A massive hemorrhage into a thyroid adenoma of sufficient magnitude to produce respiratory obstruction necessitating emergency surgical treatment is indeed rare. Wendel [1] reports the case of a patient 55 years old with sudden asphyxia and choking, unconsciousness, and a tumor in the neck. Emergency treatment consisted of opening the tumor mass, followed by marked improvement, and later taking the patient to a hospital, still unconscious, with surgical removal of the remaining abnormal tissue. The patient, however, failed to gain consciousness and died. Hertzler [2] states: "Hemorrhage into a substernal goiter may suddenly increase the volume of the tumor. One of my patients, known to have a substernal goiter, suffocated during the night from what was probably a hemorrhage into the tumor." McGregor and Cornett [3] describe the spontaneous rupture of a cystic adenoma in a woman in which the hemorrhage ruptured through the capsule of the gland and infiltrated the fascial planes of the neck, spreading into the mediastinum, with a fatal outcome. These authors cite five other instances from the literature of massive thyroid hemorrhage producing marked respiratory obstruction. Clute [4] reports on a 36-year-old woman who experienced sudden pain, dysphagia, and swelling in her neck without respiratory symptoms, and who was treated by surgical removal of an adenoma of the thyroid gland the following day, with recovery. A review of the literature reveals more frequent occurrence of acute hemorrhage of considerable degree into thyroid adenomata producing pain, tenderness, visible and palpable tumor, and dysphagia. These symptoms appear to be commoner than those of respiratory obstruction and usually are of a self-limiting nature, not requiring emergency surgical relief.

Massive hemorrhage in thyroid nodules has been described as following mild to severe muscular activity, although on some occasions it has apparently been spontaneous, without any particular physical stress. In most cases the hemorrhage remains encapsulated within the thyroid gland, although several cases have been reported (von Ziemacki [5]; McGregor and Cornett [3]) in which the blood extravasated into the subcutaneous tissues of the neck and chest walls.

The following case is of special interest in that the patient had a recurrent goiter with acute massive hemorrhage which produced a mass in the neck. This mass was enlarging at a noticeable and visible rate and produced progressive acute respiratory obstruction, necessitating emergency surgical relief.

Report of a Case

A 68-year-old woman was seen in the emergency room at St. Joseph's Hospital, Phoenix, Ariz., March 3, 1957. She gave a history of having awakened in the morning feeling in normal good health. While preparing breakfast, however, she had noted a swelling in the left side of her

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neck, which increased progressively and painlessly. Every few minutes she would look into a mirror and note an increase in the size of the lump. Gradually she developed difficulty in breathing, and when she would turn her head to the left, sit up, or stand, she would become cyanotic and have choking.

Her past history was one of good general health except for hypertension, of several years' duration. She stated that she had had a very large goiter removed 20 years previously. For the past three or four years she had noted a small lump in the left side of her neck, which gradually had achieved the size of a walnut.

Physical examination revealed an acutely ill, moderately obese woman with cyanosis. On her turning her head to the left, sitting up, or standing, the cyanosis became more prominent, and she would have increased dyspnea and choking. By turning her head far to the right, she would greatly relieve the symptoms. Pertinent physical findings included a large, nontender, firm mass, occupying a large area of the left and anterior portions of her neck and extending laterally to the sternocleidomastoid muscle, far to the right of the midline of the anterior surface of the neck, within 2 fingerbreadths of the mandible, superiorly, and below the clavicle, inferiorly. The mass increased noticeably in size over a period of approximately 20 minutes of her examination in the emergency room. Blood pressure was 210 mm. Hg systolic and 120 mm. diastolic. A scar from a previous thyroidectomy incision was present. The larynx was palpably displaced rather far to the right

Roentgenogram of the neck, illustrating the marked displacement of trachea and hyoid bone to the right side by the hemorrhagic thyroid adenoma.

side of her neck. On the way to the operating room for emergency surgical treatment, the patient was taken to the x-ray department (Figure). The clinical diagnosis was massive hemorrhage into a recurrent nontoxic thyroid adenoma with acute respiratory obstruction. The x-rays of the neck confirmed the pronounced displacement of the trachea to the right by the acute tumor.

In planning the treatment, it was apparent that the large tumor had extended across the midline on physical examination, thus making an attempt at tracheotomy very difficult. Anesthesia was carried out by Dr. Paul Sadler. An attempt was made to do an orotracheal intubation, under topical cocaine spray; but this was unsuccessful, because of the marked distortion of the larynx to the right of the midline. A small amount of thiopental (Pentothal) sodium was injected intravenously, and, by direct laryngoscopy, Dr. Sadler was able to perform an orotracheal intubation. From this point on, the patient's respiratory exchange was adequate, and the acute emergency of her respiratory obstruction was relieved. Operation was then carried out under general anesthesia through a routine secondary thyroidectomy incision. Exploration revealed that the tumor mass was a very large adenoma in the left lobe of the thyroid gland that had dissected down into the mediastinum and had encircled the trachea posteriorly. This lobe was gradually mobilized and subtotal resection carried out. After this was done, the right side of the neck was explored, and no thyroid tissue could be identified. After removal of the tumor, the trachea and larynx rapidly moved back to normal position.

At the completion of the thyroid resection, it was anticipated that a tracheotomy might be necessary to maintain an adequate airway. Before proceeding with tracheotomy, however, we decided to remove the tracheal tube and see whether her respiration would be adequate. While the trachea was held with a tracheotomy hook, the endotracheal tube was removed, and respirations were observed for approximately 10 minutes. They were quite normal, with excellent respiratory exchange, and the decision was made to omit tracheotomy. Routine closure of the incision was done after inserting a gauze pack in the area in the cavity occupied by the large thyroid tumor. The patient then proceeded to have a complete recovery, following an uneventful hospital convalescence.

Pathological examination of the left thyroid lobe disclosed a lobulated mass 12×7×4.5 cm. and weighing 190 gm. Multiple nodules were present, the largest being dissected by abundant hemorrhage. The microscopic picture was that of multiple degenerating hemorrhagic colloid adenomata.

Comment

This woman had spontaneous hemorrhage into a recurrent nodular goiter. The hemorrhage came on during normal physical activity and was painless. Bleeding into the goiter was massive and produced progressive respiratory obstruction by compression and displacement of the trachea. Treatment consisted of emergency endotracheal intubation and subtotal thyroidectomy. At the operation, it was evident that any attempt at tracheotomy prior to a thyroidectomy would have been at great risk because of the large tumor, which completely covered the trachea.

Summary

Massive hemorrhage into the thyroid gland is rare.

This complication of goiter carries risk of death, due to acute respiratory obstruction.

A case of spontaneous massive hemorrhage into a recurrent adenomatous goiter is presented, with cure by emergency subtotal thyroidectomy.

550 W. Thomas Rd.

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Tube Suction Drainage

Technique and Applicability

AARON M. SCHWARTZ, M.D., and PHILIP GLOTZER, M.D., Buffalo

The postoperative use of negative-pressure tube suction drainage to obliterate dead space and cause adherence of flaps has gained widespread popularity here and abroad in the treatment of radical mastectomy and neck dissection wounds.[1-4] A review of the literature, however, does not reveal the many other applications of this form of drainage, nor are the safeguards required in its use stressed sufficiently.

Prior to the use of this method of drainage, large, bulky dressings, with varying degrees of pressure, were employed in conjunction with soft drains, usually of the Penrose type. Profuse drainage and soaked dressings were the rule where considerable dissection had been done. The danger of bacterial inoculation of the wound attendant upon soaked dressings has been repeatedly demonstrated.[5] Frequent reaspiration, tenting of the axilla, and supraclavicular collections were common. The comfort and cleanliness of the patient left much to be desired.

In 1952, Sheppard described the sealed drainage of wounds employing closed-tube drainage without the use of suction.[6] He noted marked improvement in healing of mastectomy wounds. Raffl reported, in the same year, the use of suction drainage for radical mastectomy wounds.[7] He used a single No. 16 F. catheter brought out through a stab wound in the lateral flap and attached to a Wangensteen apparatus. Since then, several standard texts have advocated this method in neck and breast surgery.[8-9]

Submitted for publication Feb. 6, 1958.

Roswell Park Memorial Institute.

This work was done on the Surgical Division of the Montefiore Hospital, N. Y.

We have used tube suction drainage following radical mastectomy, radical neck dissection, composite neck dissections, ventral hernia repair,[10] interscapulothoracic amputation, hemipelvectomy, radical groin dissection, radical vulvectomy, and abdominoperineal resection. We have found that the patients are more comfortable, ambulation is easier, and infection, hematomas, and sloughs are less frequent. It is noteworthy how easily the obese and elderly patient can be treated by this method.

This type of drainage, following mastectomy and neck dissection, is clearly described elsewhere; however, we have found it useful to employ two catheters, No. 16 or No. 18 F., attached to a glass Y-tube and then to suction. In the mastectomy wound, the medial catheter is placed subclavicularly and the lateral one in the axilla. Both catheter tips are sutured at the point where they are placed with a single loop of a fine absorbable surgical (gut) suture. This is necessary to prevent the catheters from touching or pressing upon the axillary vessels at any point. The catheters in the neck dissection must be so fixed that they cannot impinge upon the carotid artery or any of its branches. It is imperative that the rubber catheter be sufficiently rigid to avoid collapse under negative pressure. The catheter is brought out through a stab wound to provide an airtight system. It is helpful to attach both catheters to suction prior to the initial operative dressing. This draws out the air, and the flaps mold into place. A light form-fitting dressing is then applied.

Various authors have mentioned the low incidence of primary wound healing and

the high incidence of wound complications in radical groin dissections.[11-13] As recently as 1953, Twombly reported failure of primary union in approximately half of his patients.[14] We have used suction drainage in such cases for the past two years, with striking improvement in wound healing. In bilateral groin dissection combined with vulvectomy, a pressure dressing, applied in a figure-of-eight fashion, is used in addition to tube suction. Transplantation of the sartorius is done to protect the femoral vessels from the overlying tube.[15-16] This procedure also eliminates considerable dead space. Primary union is the rule where complete obliteration of dead space is achieved. Naturally, this method cannot correct errors in fundamental surgical principles.

The good results with this method suggested its use in the management of the perineal wound after abdominoperineal resection. Perineal wounds are notoriously poor in primary healing. The wounds are difficult to dress; drainage is profuse and frequently foul. Suction drainage used in 15 cases has shown marked improvement in the postoperative course of these patients. Healing is prompt. The dressings remain dry, and the wounds are not macerated. The nursing of a patient after an abdominoperineal resection is reduced to a simple task. In all cases, early closure of the perineum has occurred after removal of the tube, and none of these wounds has broken down.

In our technique the perineum is closed in two layers. A No. 20 F. catheter with multiple openings is inserted up to the resutured peritoneal floor and brought out through the anterior aspect of the wound, which is closed snugly about the tube. The tube is attached to suction for nine days. A streptokinase-streptodornase (Varidase) solution is instilled into the catheter every other day to liquefy any clots or viscous drainage. Early ambulation is practiced and the suction detached several times daily to facilitate ambulation.

The more efficient the suction the less drainage there is. This statement appears paradoxical; however, consideration of the mechanism demonstrates that the maximum amount of negative pressure will cause complete adherence of flaps and obliteration of dead space in a dry wound. With flaps completely adherent over the entire surface area, drainage is minimal. Tube drainage, using sump drains, appears to be of no added value when this mechanism is understood.[17]

Because of the remarkable improvement in the after-care of patients treated by drainage in this manner, this procedure should be brought to the attention of the medical profession. This is particularly urgent in this era of surgery for poor-risk patients, with rising hospital costs and an increasing frequency of postoperative infections.

Summary

With the use of tube suction drainage in various major operative procedures in which large flaps are dissected, considerable improvement in wound healing is noted. Trial of this method for the care of perineal wounds following abdominoperineal resection has been successful.

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Congenital Absence of the Gallbladder and Cystic Duct

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Familiarity with the congenital anomalies of the gallbladder and the biliary tract is essential to assure accurate clinical diagnosis and proper management of disorders in this system. It is difficult to give a precise estimate of the incidence of all the aberrations which have been observed in these structures, but they are generally said to occur in approximately 10% of necropsies (Banks and Lawrance). Many of the congenital variations are of no clinical significance, for they may persist throughout life without inducing symptoms. A substantial percentage of anomalies of the gallbladder, however, is responsible for pathological changes in the bile ducts, which, in turn, predispose the latter to inflammation and stone formation. This is true of the symptomatic patient with congenital absence of the gallbladder and cystic duct.

The presence of this anomaly and the concomitant derangements which it may occasion in the adjoining bile ducts can only be educed in direct proportion to the index of suspicion which the clinician evinces. No case has ever been diagnosed correctly before operation, and treatment of the condition has been erratic. A fundamental understanding of the nature of this aberration, as well as of its associated sequelae, will lead to its proper management.

Congenital absence of the gallbladder and cystic duct in the presence of a normal hepatic and common duct system, is one of the rare anomalies of the biliary tract. It has been observed with equal frequency, according to the literature on this subject, at operation and at necropsy. Clinically, it is usually encountered during laparotomy for symptoms which are presumed to be due to disease of the gallbladder, more especially calculus cholecystitis and/or to obstruction of the common bile duct. At necropsy it has invariably been reported to be an unsuspected, incidental finding.

Congenital absence of the gallbladder is said to have been known to Aristotle (384-322 B. C.), but the first pathological report of this condition was published by Lémery fils in 1701 A. D. In 1902 Gay reviewed 19 cases in the medical literature and added a description of one of his own patients. Dixon and Lichtman were able to collect 50 instances of this derangement from the literature (1945), and they analyzed 10 cases from the records of the Mayo Clinic. Rodda and McBurney noted that there have been 104 published cases of agenesis of the gallbladder since 1900. To date, 115 instances of this condition have been recorded (Jutras and Rice). The information relating to many of the cases which were described in the literature was found to be incomplete.

We became interested in agenesis of the gallbladder when the condition was encountered in a patient who was operated upon for what appeared clinically to be chronic calculus cholecystitis and choledocholithiasis. A review of the files of the Brooklyn Jewish Hospital revealed that no other instance of this disorder has been encountered in a clinical patient.

A search of the necropsy material of the hospital from 1930 to 1957 indicated that in four recorded cases congenital absence of the gallbladder was an incidental finding. None of these patients gave a history of abdominal operation, nor were any laparotomy scars seen at autopsy.

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It is proposed in this paper to describe the aforementioned five cases. On the basis of an analysis of these cases, and in the light of the literature reviewed, some of the salient features relating to the incidence, pathogenesis, pathology, symptomatology, and treatment of agenesis of the gallbladder and cystic duct will be discussed.

Report of Cases

CASE 1.—A 74-year-old man was admitted to the hospital on Jan. 4, 1952, with the presenting symptoms of epigastric pain, nausea, vomiting, malaise, and increasing jaundice, of one week's duration.

The patient gave a history of vague epigastric distress and fullness for many years. This symptom usually occurred postprandially and was accompanied by belching. There was also a sensitivity to "heavy" meals and spices.

About one year before the onset of his present illness, he began to have recurrent attacks of colicky epigastric pain, which came on at any time of the day or night. These episodes occurred at intervals of 10 to 12 weeks and subsided spontaneously in a few hours. There appeared to be no relationship to food intake. Gastrointestinal x-ray examination was negative. Two months before admission to the hospital the pain appeared to radiate to the right side. The patient experienced chills, and the temperature rose to 102 F. The fever subsided after five days. Roentgenographic study of the gallbladder gave no visualization of this viscus. The last attack began one week prior to hospitalization. It was accompanied by jaundice and a low-grade fever. The stools were "light"-colored, and the urine was dark and foamy.

A past history was elicited of mild diabetes, which was easily controlled with diet without the use of insulin. The patient had also shown electrocardiographic evidence of arteriosclerotic myocardial changes, without any clinical manifestations.

On admission the patient appeared to be a well-developed, well-nourished, moderately icteric man, in mild distress. The temperature and pulse rate were normal. The heart and lungs were not unusual. Moderate peripheral arteriosclerotic changes were seen.

The abdomen was soft but slightly distended. There was moderate diffuse tenderness throughout, especially in the epigastrium, where voluntary spasm was also noted. No lumbar tenderness or masses were noted. Rectal examination was normal.

Peripheral blood examination showed 75% hemoglobin, 5,120,000 red blood cells, and 5000 white blood cells per cubic millimeter. The differential study revealed 62% neutrophilic leukocytes, 1% band forms, and 37% lymphocytes. The urine gave a 3+ reaction for bile and a trace of albumin.

The blood chemistry figures were as follows: urea nitrogen 20 mg. %; sugar 145 mg. %; CO_2 content 24 mEq/L.; total protein 6.4 gm. %; albumin 3.2 gm. %; globulin 3.2 gm. %; serum A/G ratio 1.0; total cholesterol 168 mg. %; free cholesterol 71 mg. %; icterus index 32.5 units; direct van den Bergh positive; indirect 0.5 unit per 1000 cc. of serum; alkaline phosphatase 14 Bodansky units. The prothrombin time was 9.9 seconds; the control, 14.5 seconds. Thymol turbidity was 3.0 Maclaglan units. The stool was acholic and contained no occult blood. The clinical impression was that of recurrent cholecystitis and choledocholithiasis.

The patient was operated upon under general anesthesia through a right rectus incision. The liver, pancreas, and gastrointestinal tract were not unusual. A thorough search of the biliary system failed to reveal the presence of a gallbladder or cystic duct. There was a dense strand of connective tissue on the inferior surface of the liver, which traversed a shallow fossa vesicae felleae. The common bile duct was thick-walled, and the lumen appeared to be wide. In its distal portion there were turbid bile and thick bile sludge.

The common bile duct passage was opened. The sludge was removed, and the duct was irrigated. A catheter was passed easily into the duodenum, as did moderate-sized Bakes dilators. A T-tube was sutured in the common duct, and the abdomen was closed.

Recovery was uneventful. Cholangiography through the T-tube 12 days after operation revealed normal, though somewhat dilated, bile passages. The T-tube was removed three weeks after operation. The patient was well for three years and then died after an attack of acute coronary disease.

CASE 2.—A 22-month-old male child was admitted to the Brooklyn Jewish Hospital on Sept. 30, 1930, with the symptoms of severe diarrhea, fever, weakness, dyspnea, and evidence of acute cardiac decompensation. There was a past history of bouts of diarrhea for one year before admission, as well as an episode of pneumonia during that interval.

Soon after his admission to the hospital the cardiac symptoms became severer, and the patient died.

At necropsy the chief pathological anatomical finding was agenesis of the gallbladder and the cystic duct. A thin strand of connective tissue was present at the usual gallbladder site, where a

fine fissure was noted on the liver surface. The bile passages were normal.

The other anatomical findings were acute and chronic myocarditis, subacute and chronic glomerulonephritis, interstitial hepatitis, chronic passive congestion of the liver, and adrenal hemorrhage.

CASE 3.—A 32-year-old man was admitted to the hospital on Sept. 18, 1940, with a history of having had a nevus of the face excised the year before, which proved to be a malignant melanoma. He showed clinical evidence of extensive spread to various organs, ran a rapid downhill course, and died.

Autopsy revealed congenital absence of the gallbladder and cystic duct. No fossa vesicae felleae was evident. The extrahepatic biliary tree was entirely normal.

The other anatomical findings were melanoblastoma in the skin, lymph nodes, pleura, lungs, adrenal glands, right kidney, and brain. Subsidiary findings were patent foramen ovale, cyst of the right kidney, and duodenal ulcer.

CASE 4.—An 83-year-old man was admitted to the hospital on April 15, 1950, in a semicomatose condition. He had complained of acute abdominal pain about 18 hours before admission, and this had become progressively worse. On examination the entire abdomen was found to be tender and spastic. Parenteral fluids, electrolytes, and blood were being administered, in preparation for operation, a few hours after admission when the patient suddenly became dyspneic and cyanotic and died. The clinical impression was that of acute mesenteric thrombosis.

At autopsy the pathological anatomical report was congenital absence of the gallbladder and cystic duct. The extrahepatic bile ducts were normal. The cause of death was a perforated chronic duodenal ulcer and generalized peritonitis. Subsidiary anatomical findings were myofibrosis cordis, arterial and arteriolar nephrosclerosis, hamartoma of the right kidney, hypertrophy of the prostate, and generalized osteoporosis.

CASE 5.—A 55-year-old man was admitted on Sept. 13, 1945, with a history of chest pain, dyspnea, and weakness, of one day's duration. Clinical and cardiographic evidence of massive coronary closure was seen. There was also a history of diabetes mellitus, and of posterior-wall infarction one year before admission.

The patient died two days after onset of the present illness. Necropsy revealed congenital absence of the gallbladder and cystic duct. The biliary ducts were normal. The other anatomical findings were right coronary artery thrombosis, myomalacia and myofibrosis cordis, and nephrosclerosis.

There was an unusual extension of the gastrohepatic omentum as a continuous fold, which extended from the upper surface of the duodenum to the underside of the quadrate lobe of the liver and the porta hepatis (hepatoduodenal ligament).

Incidence

The incidence of agenesis of the gallbladder which has been observed at necropsy has varied in different reports in the literature. The following are some of the published figures:

Author	*No. of Cases Reported*	*Autopsies*
Everett and Macumber	3	1,300
Mouzas and Wilson	9	21,631
Knox	2	2,000
Mentzer	1	1,600
Gordon and Dragutsky	1	3,660
Tallmadge	12	18,350
Pines and Grayzel	4	6,112

In general the incidence in different clinics ranged approximately from 0.035% to 0.065%; the highest one reported was 0.3%. Many cases undoubtedly have been seen which are not recorded.

The number of published cases of gallbladder agenesis appear to be almost equal among clinical patients and at autopsies (Polivy and Sachs). Latimer et al. found 34 living persons in a collected series of 71 patients. Hillemand et al. noted 40 such persons among the 90 cases of agenesis that they studied, and Mann was able to find 38 clinical patients among 75 cases of agenesis.

The distribution between the sexes was observed to be equal in the cases of agenesis of the gallbladder which were identified at necropsy. In the clinical group of patients, however, the incidence appeared to follow the general predominance of biliary-tract conditions in women; it was two to three times as frequent in women. Our patients were all male.

Gallbladder agenesis has been observed in persons of all ages, from early childhood and infancy to old age. Bower was able to find 22 cases in the literature in persons below the age of one year. Latimer et al. collected 68 cases in adults from the medical reports, the oldest patient being 84. The ages of the patients who came to surgery ranged from 19 to 70 (Flannery and Caster). The average age at which this

anomaly was identified was 46 years. The age of the youngest patient cited in this paper was 21 months; that of the oldest, 83 years.

Etiology

The etiology of this condition is obscure. The most commonly accepted theory is that it is the result of a disturbance of embryonal development. A review of the embryonal growth of the biliary system is pertinent at this point in order to clarify this hypothesis.

The anlage of the liver, its ductal system, the gallbladder, and the cystic duct, arises as a single primordial growth of cells, known as the hepatic diverticulum. This appears to arise from the entodermal lining of the ventral surface of the foregut just cranial to the yolk sac during the 14-somite stage of fetal development. From the cranial portion of the diverticulum two solid buds of cells proliferate ventrally and cephalically to form the lobes of the liver, while the narrow, elongated proximal portion of the diverticulum persists as the hepatic and common bile ducts. Caudally, the anlage of the gallbladder and cystic duct arises as a smaller bud of cells from the proximal, inferior aspect of the hepatic diverticulum at a point near the confluence of the two hepatic ducts. The primordial gallbladder bud elongates rapidly and it becomes saccular, while the narrow, proximal part becomes the cystic duct.

When the embryo is 15 cm. long, the gallbladder passes through a solid stage, and it appears as a solid cylinder in the hepatic fossa. A lumen is formed later by a process similar to that which is seen to occur in the development of the intestinal tract. Vacuolation of the epithelial cells takes place, and subsequently coalescence of the vacuoles creates a lumen simultaneously in different parts of the developing gallbladder. In the seventh week, when the lumen is reestablished, the gallbladder appears as an offshoot of the common bile duct, lying in the free edge of the ventral mesentery.

It is the failure of the embryonal development of different portions of the anlage or its retardation at various phases of its differentiation that apparently causes the anomalous formations or absence of different parts of the hepatobiliary tract. When the caudal anlage of the gallbladder and cystic duct fails to bud from the hepatic diverticulum, there is total agenesis of the gallbladder and cystic duct. Latimer et al. found that the cystic duct was absent in 15 of 34 patients who were operated upon and in 18 autopsy cases. Dixon and Lichtman observed that the cystic duct was present only in 4 of the 60 cases they reviewed. It was nonexistent in all the cases described in this paper. The fossa vesicae felleae is usually lacking in patients in whom the gallbladder fails to develop; for this reason, the quadrate lobe may be absent, or it may be poorly delineated. Occasionally, a shallow fissure or a dimple and a thin strand of connective tissue is visible on the inferior surface of the right lobe of the liver. Latimer et al. noted 33 cases of this type in the literature. Two of the cases cited in this paper also presented these elements.

When arrest in development occurs during the solid phase, there may be seen in the gallbladder fossa a dense, atretic band of connective tissue. Bower was able to find four such instances. In the event that only a partial vacuolation and coalescence takes place after the solid phase of fetal growth, there may be found rudimentary bladders of varied sizes and proportions. An example of a vestigial type of gallbladder was observed by us; the details are being published in another paper, which is concerned with anomalies of this nature. It becomes obvious from the above discussion of the embryonal growth of the biliary tree that many permutations and combinations of structural maldevelopment may occur in this area.

It is maintained by some writers that at least some of the cases of agenesis are due to local specific (Syphilitic) disease or to non-

specific inflammation which may take place in fetal life. Others indicate that a hereditary factor may be the cause of this aberration. Kobacker described the condition in two sisters, and he indicated that cholecystographic studies in three other siblings also pointed to the absence of the gallbladder.

Studies of the comparative anatomy of this region have led to the speculation that the absence of a gallbladder in man may be an evolutionary manifestation. Mentzer noted that humans are not the only species in which the gallbladder may be nonexistent. He observed that the gallbladder is normally absent in 36 species of herbivorous mammals, in 9 species of birds, and in 17 species of fish. Among some of these are the horse, mule, deer, and camel. In other animals the gallbladder may or may not be present, i. e., in the giraffe and the elephant. In some species, such as the Petromyzon and the pigeon, the gallbladder develops in embryonal life and disappears in later development. These observations caused Iovetz-Tereshchenko to speculate whether Homo sapiens, as a species, is beginning to lose his gallbladder or whether, on the contrary, he has almost acquired it.

Associated Congenital Anomalies

Absence of the gallbladder may be accompanied by other congenital abnormalities in the body, both in the hepatobiliary system and elsewhere. Anomalous conditions of the bile passages have been described in association with this condition. Förster, in 1865, observed aberrant hepatic ducts which emptied separately into the duodenum; in other instances, one duct opened into the duodenum and another into the stomach, or even into the colon. Everett and Macumber described one case in which there was a high bifurcation of the common bile duct; one branch emptied into the duodenum and another into the stomach. In a review of 200 cases of congenital atresia of the bile ducts, Gross indicated that gallbladder atresia was present in one-sixth of the patients.

Latimer et al. specified that there was a variation in the anatomy of the liver in 13 of the 71 cases of gallbladder agenesis which they reviewed. These variations consisted of atrophy, hypertrophy, a large Riedel lobe, and absence of the left or quadrate lobe of the liver.

Rains and Villareal each described a case in which there was an associated abnormality of the lesser omentum. A membrane extended from the anterosuperior surface of the duodenum to the inferior aspect of the quadrate lobe of the liver and the porta hepatis; it appeared to be continuous with the gastrohepatic ligament. A similar structure was described by Waugh, who was of the opinion that it represented a persistent primitive anterior mesogastrium, between the two layers of which the gallbladder usually develops. An analogous membrane appeared in one of the cases described in this paper (Case 5).

Gallbladder agenesis has also been seen to occur concomitantly with anomalies in other organs. Blakeway called attention to its conjoint occurrence with imperfect development of the pancreas and imperforate anus. Askenazy found pancreatic tissue in the walls of the stomach and duodenum. Danzis observed that the condition may be accompanied by congenital derangements of the ears, palate, and spleen (supernumerary) and by megacolon and imperforate anus. None of our cases contained any associated anomaly.

There appears to be no description of the vascular tree of the biliary tract in patients showing absence of the gallbladder either in the literature or in our necropsy records. A study of the vascular pattern would be of great interest.

Associated Pathological Changes

Some authors have observed that patients who have congenital absence of the gallbladder are inclined to show some anatomical and physiological changes in the bile passages. This has been the subject of controversy. Mouzias and Wilson, and

Gross express the belief that this condition does not initiate alteration in the structure or function of the biliary channels. Among the cases which are recorded in this paper, only the clinically symptomatic patient showed morphological and pathological changes in the common bile duct. The majority of writers agree with Caylor that, as a result of agenesis of the gallbladder, there occur structural, physiological, and pathological changes in the bile passages.

The morphological alteration most commonly mentioned is that of dilatation of the extrahepatic biliary tree, especially the common bile duct. Förster, in 1865, and Waring, in 1897, called attention to this condition. Other authors subsequently made similar observations, and they conjectured that this was similar to the change in the ductal system which was described as occurring in patients after they had been cholecystectomized (Robson). Dixon and Lichtman indicated that it existed in 31% of the cases of agenesis that they reviewed; others have observed it in up to 40% of the cases. Higgins also found it in some species of animals which are not provided with gallbladders.

It is maintained that the reason for the widening of the common bile duct in these patients is the imbalance in the intraductal pressure which is occasioned by the absence of the gallbladder. The gallbladder functions as a storehouse and concentrates the bile, which is secreted continuously at the rate of 20 ml. per kilogram of body weight in 24 hours (Gorham). Expulsion of the stored bile into the duodenum depends upon the integral relation between the contractions of the gallbladder and the tonicity of the sphincter of Oddi. The tonus of the gallbladder and its contraction are essential to potentiate relaxation of the sphincter; its absence increases the tonic state of the sphincter and causes dilatation of the duct. In some instances the valve may even be thrown into spasm (Spellberg). This hypothesis has not been scientifically substantiated.

Mann theorized that in the absence of the gallbladder there was ampullary dysfunction, which was followed by bile stasis and dilatation of the ducts and, finally, by sedimentation of bile and stone formation. He noted that common-duct stones were found in 13 patients who were treated surgically. Villareal commented that 18 of the 37 clinical patients he reviewed showed common-duct dilatation and calculi. Dixon and Lichtman reported the incidence of concretions in the cases they reviewed to be 27%.

Less commonly there was seen in some of these patients a localized cystic type of dilatation of the common bile duct, in the lumen of which stones were present. The widening of a segment of the duct in these patients appeared to be due to a stenotic stricture of the tube proximal to the sphincter of Oddi, and not to dyssynergia of the sphincter of Oddi, since the common bile duct distal to the stenosis was of normal dimensions. Rheinlander and Bowens described a case of cystic dilatation measuring 5 cm. in diameter. Rolleston (1912) cited a similar instance published by Cruckenell in 1873, in which the common hepatic duct was described as opening into the gallbladder and the common bile duct as coming off separately, so that the bile all passed through the gallbladder. Rolleston believed this to be an instance of absence of the gallbladder with compensatory dilatation of the common duct. Petersen and Walton each described similar conditions in other patients. However, they hypothesized that the wide cystic areas were anomalously placed gallbladders which appeared to be continuous with the common duct because of the congenital absence of the cystic ducts. Judging from the description, however, it could also be conjectured that the pouches in these patients represented localized cystic dilatations of the common duct in the absence of the gallbladder.

In some instances, absence of the gallbladder is accompanied by pathological

changes in other organs. Dixon and Lichtman reported the presence of chronic pancreatitis in 21% and cirrhosis of the liver in 21% of the 60 cases they reviewed.

Of the four necropsied patients described by us, two showed concomitant cysts of the kidney, and a third patient, a hamartoma of the kidney. Two of the patients had duodenal ulcers. These lesion appear to be fortuitously associated conditions.

Symptoms

Most symptomatic patients whose gallbladders are congenitally absent complain of chronic dyspepsia, vague postprandial malaise, and a sense of fullness in the right hypochondrium. Some of them manifest symptoms such as recurrent upper abdominal pain, bloating, belching, fat intolerance, and nausea; these usually appear postprandially, and they may recur intermittently for years. Only rarely is the abdominal pain referred to the back, and at no time does it appear to radiate to the shoulder. The clinical patient that was described in this paper (Case 1) showed the characteristic syndrome.

Most of the clinical patients whose cases were described in the literature had symptoms which suggested the diagnosis of calculus cholecystitis. This appeared to be corroborated by the cholecystographic reports of nonfunctioning or nonvisualization of the gallbladder. Such was the case in 20 of the 30 cases which were reviewed in the literature by Rodda and McBurney and in 25 of the 36 cases assembled by Dixon and Lichtman.

Symptoms associated with common bile duct involvement were observed in almost 60% of the clinical patients. Abdominal pain and obstructive icterus were prominent symptoms in approximately 50% of these cases. Jaundice due to stones in the common duct in the absence of the gallbladder was once thought to be rare (Polivy and Sachs), but it was reported by Dixon and Lichtman in 28% of the cases that they reviewed, by Mann in 34% of the cases, and by Flannery and Caster in 50%. The presence of calculi in these patients substantiates Carter's contention that concretions may form in the bile ducts.

In a few instances the complaints were characteristic of Charcot's intermittent hepatic fever, i. e., fever and chills with or without jaundice. These symptoms pointed to a diagnosis of choledocholithiasis and cholangitis. Mann noted six such cases in a review of the literature. This has subsequently been corroborated by other authors.

There is no pathognomonic syndrome to indicate that the gallbladder is absent. For this reason, and because of its rarity, a diagnosis of this condition has never been made clinically.

Treatment

Any surgeon may unexpectedly be confronted with the problem of the absent gallbladder during celiotomy for intra-abdominal disease. A knowledge of the facts previously described in this paper relative to the associated diseases and anomalies, as well as of the complications which may accompany gallbladder agenesis, will contribute immeasurably to the rational management of the patient.

It is of prime importance, however, for the operator to establish first whether the gallbladder absence is apparent or real. This may offer a challenge to even the most experienced surgeon, for the organ may not be visualized for any of the following reasons:

1. It may be lying in an obscure, abnormal position, such as (*a*) under the inferior surface of the left lobe of the liver (16 cases recorded in the literature [Etter, 1953]); (*b*) between the blades of the falciform ligament (1 case published by Nelson et al., 1953); (*c*) in a transverse position (2 cases reported by Gross, in 1936); (*d*) retroperitoneally (1 case described by Rachlin), and (*e*) within the substance of the liver.

The last-mentioned position is the commonest aberrant site of the vesicle. The gallbladder may be concealed at various depths from the surface of the liver. Needling has been recommended as a method of diagnosis, but it is unreliable, since bile may be obtained from a dilated duct. Retrograde cholangiography is the best method available for detection of this condition, but is also subject to error.

2. Visualization of the gallbladder may also fail when the organ is atrophic or hypoplastic. It may be replaced by a shrunken, obliterated mass of connective tissue, as a result of repeated attacks of chronic inflammatory disease with fibrosis.

3. The gallbladder may have been excised at a previous operation.

4. Finally, it may be congenitally absent.

When it is ascertained that the condition is one of agenesis, the operator should then explore the region of the common duct in order to locate any possible remnants of cystic duct or of hypoplastic or atretic gallbladder. These are excised if they are located.

In the absence of any apparent pathology other than gallbladder agenesis encountered in the course of laparotomy for upper abdominal symptoms, various procedures were followed by different authors; but, in the light of analysis of the literature on this subject, it appears that the management that has met with the greatest success consists of common-duct exploration and the use of an indwelling T-tube.

Flannery and Caster have pointed out that the majority of patients who showed gallbladder agenesis and the presence of apparently normal bile ducts continued to have the same symptoms that they displayed before operation when T-tube drainage was not performed. Simply doing an appendectomy and closing the abdomen, as has been described by some writers, is completely inadequate. Common-bile-duct exploration is indicated in every case of symptomatic gallbladder agenesis also for the reason that calculi may exist without there being any perceptible dilatation of the bile passages.

Close scrutiny of the literature relating to congenital absence of the gallbladder reveals that various operative procedures were performed by the different surgeons. These were successful only when the operation was adapted to the individual needs of the patient. This depended largely upon the nature of the associated pathological anatomical conditions, which appeared to occur as sequelae of the absent viscus. In some instances in which ampullary dysfunction was suspected to be the cause of the patient's symptoms, even in the absence of common-duct dilatation and/or calculi, sphincterotomy in conjunction with T-tube drainage was performed with success (Mann). This procedure appeared to be indicated especially when the common-bile-duct passage was wide and no calculi were present. In other cases of gallbladder agenesis in which the common duct was dilated to cystic proportions, a Roux-en-Y choledochojejunostomy was successful in two instances, and in two others a resection of the cystic area and an end-to-end anastomosis of the common duct resulted in a cure.

When stones were present, choledocholithotomy, prolonged T-tube drainage, and sphincterotomy were the preferred treatment. The T-tube was permitted to remain for variable periods of time, depending upon the nature and extent of the pathology, the type of procedure performed, and the presence of calculi in the bile passage. In most instances, prolonged drainage gave optimal results.

Other organs are to be closely examined during the course of abdominal exploration in these patients, including the stomach, duodenum, liver, and the remainder of the gastrointestinal tract, for biliary symptoms may not uncommonly be initiated by various conditions extrinsic to the hepatobiliary tree. It is also important to deter-

mine the status of the pancreas because of the frequency with which pathological changes have been observed in this organ when the gallbladder is congenitally absent.

Summary

Congenital absence of the gallbladder and cystic duct in the presence of normal biliary passages is a rare anomaly, and has been observed with almost equal frequency at operation and at necropsy.

Preoperative diagnosis of this condition has never been made. It is usually encountered during the course of celiotomy which is performed for symptoms that are suggestive of calculus cholecystitis and/or choledocholithiasis. When it is observed at necropsy, it is an unsuspected, incidental finding.

Agenesis of the gallbladder and cystic duct has been reported in patients of ages ranging from earliest infancy to 84 years.

Five new cases are described in this paper. One was that of a symptomatic patient 74 years of age; the other four were culled from the necropsy files of the Jewish Hospital in Brooklyn.

The embryonal development of the hepatobiliary tree is reviewed in order to elucidate the etiology of this condition.

Emphasis is placed upon the fact that congenital absence of the gallbladder and cystic duct predisposes the bile passages to anatomical and physiological derangements, which, in turn, lead to inflammation of the bile ducts and stone formation in a large percentage of cases. An understanding of the nature of the pathological sequelae which are associated with gallbladder agenesis is vitally important to assure rational management of these patients.

Although no pathognomonic clinical syndrome exists to indicate absence of the gallbladder, there is generally a consistent symptom pattern which may alert the clinician who has a high index of suspicion.

Definitive surgical treatment is indicated in all symptomatic patients in whom the gallbladder and cystic duct are congenitally absent. The procedures vary with the nature of the associated alterations in the bile passages. These are discussed in the light of the literature reviewed on this subject.

25 Eastern Parkway.

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Dacron Prosthesis for Coarctation of Aorta with Aneurysm

Report of a Case in a Pregnant Woman

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Since 1949, when Gross [10] published the first cases of aortic grafts for coarctation, several surgeons have reported similar successful cases (Dubost,[6,8] Oeconomos,[14] Brock,[15] Sellors,[16] Cooley [2]).

In a total of 14 coarctations successfully operated upon, we encountered 2 aneurysms, of which the first was lying on an intercostal artery and the second on the descending aorta. The cases concerned women 28 and 29 years of age, respectively. In the first case, after the resection of the stenosis with the intercostal aneurysm, an end-to-end anastomosis was easily obtained, whereas in the second case, owing to the size of the aneurysm and its localization, a Dacron reconstitution of the aorta was performed.

The above-mentioned case that concerned a pregnant woman aged 28 is reported both for its rarity and for its interest.

Report of Case

History.—Mrs. A., aged 28, primipara, in the second month of pregnancy, consulted me with the chief complaint of arterial hypertension with headaches and tachycardia, especially on effort. From the clinical examination it was easily proved that the arterial hypertension was due to a coarctation of the aorta.

Clinical Examination.—The physical and intellectual status was normal. She was in the second month of pregnancy and presented a quite visible hyperpulsatility of the vessels of the neck. There was no cyanosis or clubbing of the fingers. Pulsations were found along the intercostal spaces, particularly over the upper half of the back.

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From the Department of Thoracic Surgery, Athens Polyclinic.

Examination of Heart.—There was no thrill. The apex beat was strongly evident in the left fifth intercostal space.

A systolic, ejection type, murmur was found in the left second intercostal space but was also heard easily in the back.

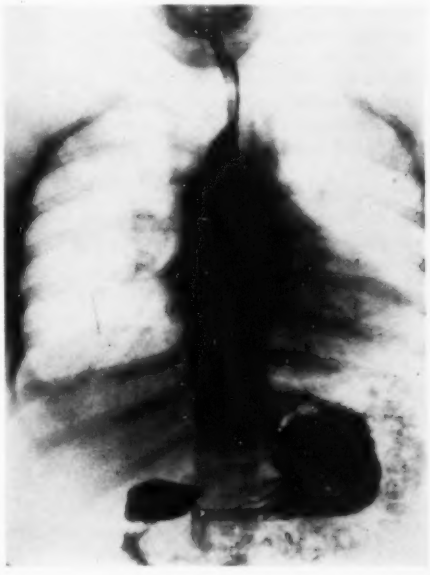
The pulse was easily palpable and full in both arms but was completely absent in the femoral arteries.

The blood pressure was 200/100 in the arms and 110/70 in the legs. Oscillometry showed 5 in both arms and only 1/2 to 1 in the legs.

Roentgenographic Findings.—Cardiac Picture: The left ventricle was enlarged. The aortic knob lacked its normal prominence. An egg-sized shadow was noticed under the stenosis.

The notching of the ribs was visible on both sides.

Fig. 1.—Visualization of the esophagus, which is pushed to the right.



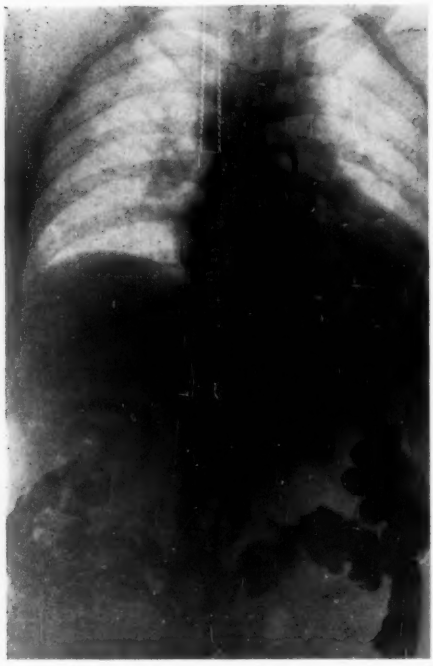


Fig. 2.—Preoperative aortogram.

Visualization of the Esophagus.—With a swallow of barium in the esophagus, this structure was pushed to the right (Fig. 1). There was evidence that the esophagus was compresed by a poststenotic, calcified aneurysm.

Angiography.—For further information, retrograde aortography was decided on. The catheter was pushed through the left femoral artery, met the resistance of the stenosis, and returned in the descending aorta, without its being possible to introduce the end of the catheter into the aneurysm (Fig. 2).

Electrocardiography.—The EKG revealed left axis deviation, intermediate heart position, and evidence of left ventricular hypertrophy. There was a nodal rhythm.

Other Tests.—The various blood and urine tests revealed no abnormality.

The gynecological examination confirmed a two months' pregnancy.

Comment.—The case was one of coarctation of the aorta, with a poststenotic, calcified aneurysm in a 28-year-old woman, in her second month of pregnancy.

Resection of the stenosis with the aneurysm, followed by reconstitution of the aorta with a Dacron prosthesis, was decided upon and performed in Oct. 30, 1956.

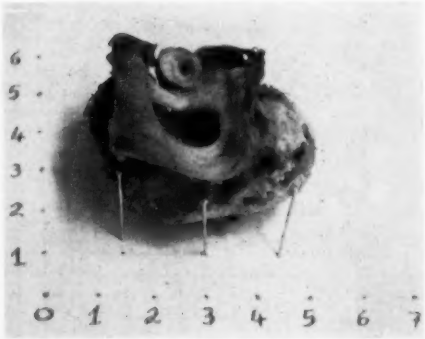


Fig. 3.—Resected part of the aorta. Note the stenosis and the calcified aneurysm.

Operation.—With the patient on her right side, the left chest was opened through the fourth intercostal space. A coarctation of the aorta (of adult type) was found. Under the stenosis was a completely calcified aneurysm the size of a normal egg (Figs. 3 and 4).

Resection both of the stenosis and of the aneurysm was obtained, not without difficulty. The reconstitution of the aorta was obtained with a Dacron* taffeta tube 8 cm. in length (Fig. 5), previously prepared and left for about one hour in a siloxane-ether solution (silicone). Suturing was performed by the everting mattress suture technique. The prosthesis was wrapped with a small piece of Dacron to assure the greatest

*Mr. Sol. Lamport put at our disposal the Dacron taffeta.

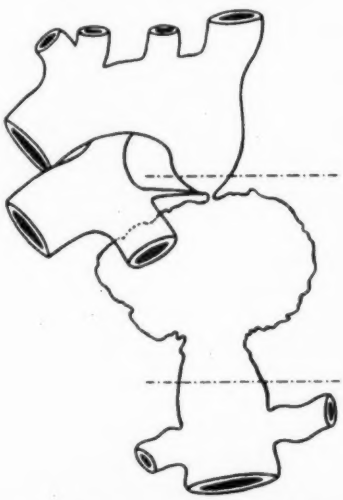


Fig. 4.—Drawing of operative findings.

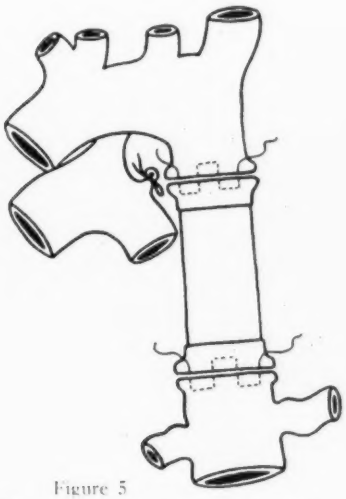


Figure 5

Fig. 5.—Drawing of reconstituted aorta.

Figure 6

Fig. 6.—Postoperative aortography, 10 months after surgery.

safety. The duration of the operation was about four hours.

Postoperatively the patient was in good condition, and the pregnancy continued favorably to the ninth month, when the patient gave birth to a normal boy, weighing 2800 gm.

Mother and baby were in excellent condition several months after parturition. The mother's blood pressure since the operation has been within normal levels (140/80), and the pulse is easily palpable in the femoral arteries.

Ten months after the operation a retrograde aortography, performed through the left subclavian artery, revealed excellent functioning of the Dacron prosthesis (Fig. 6). The patient has since been followed in the outpatient department.

Comment

Cases of coarctation with a completely calcified aneurysm of the descending aorta in a pregnant woman are not very usual. As far as we know, no similar case has so far been reported in the literature, especially of a pregnant woman subjected to an aortic transplantation during pregnancy, with an excellent result. It must be noted that the aneurysm was a calcified one of the descending aorta under the stenosis, and not in a intercostal artery, where such an aneurysm is usually found in coarctations.

The resection of a part of the descending aorta makes necessary the use of a vascular graft or prosthesis for its reconstitution.

In this case, incited by the very interesting work of Blakemore,[1] Deterling,[2-4] Edwards,[9] Creech,[12] Julian,[13] and others, we decided to use Dacron taffeta, which was previously obtained from the Lamport Brothers Company, of New York. Anticipating this operation, we used a sewing machine to prepare some Dacron tubes of different sizes, so as to be in a position to use the appropriate one during the operation. Before the operation, the tube to be used was left for at least one hour, in a siloxane-ether (silicone) solution, a detail which for us seems to be very important.

The result of this operation, together with those of similar procedures in which we used successfully the Dacron prostheses, lead us to believe that the vascular prostheses may be used with the same safety as are the vascular grafts.

Summary

The case of a woman in her second month of pregnancy, who has been operated upon for coarctation of the aorta with a poststenotic calcified aneurysm, is reported. After resection of the diseased aorta, a Dacron prosthesis 8 cm. long was used. The blood pressure dropped to a normal level after the operation; the pregnancy was carried out normally, and postoperative aortography, performed 10 months later revealed excellent functioning of the prosthesis.

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Diverticula of the Jejunum with Massive Hemorrhage

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The differential diagnosis of hematemesis and melena includes many diseases of the entire gastrointestinal tract. One of the more unusual sources of such hemorrhage is diverticula of the jejunum.

The first description of diverticula of the jejunum was made in 1844 by Cooper.[6] The patient was about 50 years old and had died of other causes. When the autopsy was done, numerous pouches were found in the greater part of the jejunum, situated chiefly between the layers of the mesentery.

The incidence of diverticulosis of the jejunum is low. Gordinier and Sampson[11] described a patient with partial intestinal obstruction due to diverticulitis occurring in a pouch located in the upper ileum or the lower jejunum. The authors collected the reports of 14,068 autopsies and found acquired diverticula of the small intestine in 16. Case[5] reported 5 such instances in 6847 patients in whom complete barium meal studies, including the routine observation of the opaque meal in its passage from the mouth to the rectum, and a supplementary barium enema were done. Three cases, or 0.09%, were found by Larimore and Graham[14] in 3446 patients having complete gastrointestinal fluoroscopic and serial film studies. Fraser[10] discovered 1 case in 5000 case records and added 1 of his own. Butler[4] collected 13 cases and added 7 of his own, for a total of 20 cases. Ten specimens, of which three had multiple diverticula and seven had one diverticulum, were reported on by Edwards,[8] who also described two cases in which the disease was demonstrated by the roentgenogram.

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Rankin and Martin[17] reported that 996 stasis examinations of the small bowel were done from 1927 to 1931 and 3 instances of diverticulosis of the small bowel were found. Of 52 patients with diverticulosis of the small bowel who were reviewed, 39 had diverticula of the jejunum and 2 had diverticula of the jejunum and ileum. Rosedale[18] discovered 3 instances of diverticulosis of the jejunum in 5000 autopsies. In 5000 complete radiologic studies of the gastrointestinal tract, no single case was found. Edwards[9] reported 4 instances of diverticulosis of the jejunum and ileum in a study of 4631 patients having a barium meal. In 2820 autopsies 9 diverticula were found. When a special search was made for the condition, 5 instances of the single or multiple type were discovered in 881 autopsies. Orr and Russell[16] found 9 cases of diverticula of the small bowel in 2161 examinations with a barium meal.

The condition occurred slightly more frequently in men than in women.[9] The average age of the patients was about 56 years.[9]

Two varieties of intestinal diverticula have been described. The congenital, or true, diverticulum is composed of all the layers of the normal intestine. The acquired, or false, diverticulum is a herniation of the mucous membrane with few or without muscular fibers in the wall. According to Mayo, Baskin, and Hagedorn,[15] most of the diverticula in the jejunum are acquired, the congenital group being represented by the rare instances of partial reduplication of the intestine.

Edwards[9] has given an extensive description of the pathogenesis and morbid anatomy of acquired diverticula of the

jejunum and of the ileum, based upon the examinations of six autopsies and three operative specimens. He reported that the diverticula were herniations of the mucous membrane along the mesenteric border of the jejunum on either side of the midline, corresponding exactly to the site of entrance of the paired mesenteric blood vessels into the wall of the intestine. The hernias did not push between the leaves of the mesenteric, however, unless they were large or they fused with the opposite fellow. Edwards [9] believed that an increase in intraintestinal pressure was necessary to produce the diverticula at these points of lowered resistance, where the blood vessels pierced the wall of the intestine. The increased intraintestinal pressure was thought to be caused by persistent, irregular intestinal contractions, the portion of the bowel containing the weakened areas being relaxed while the segment on either side was contracting. The increased pressure in the uncontracted segment caused the mucous membrane to protrude into the gaps where the blood vessels entered the intestinal wall.

Little has been found pathologically to explain the hemorrhage from jejunal diverticula. Mucosal ulceration and heterotopic tissue, such as pancreatic cells or gastric mucosa, have been reported in patients with hemorrhage from diverticula of the jejunum, but such findings are extremely rare. Tearing of the blood vessels by distention of the sac with contents of the bowel, trauma that produces submucosal hemorrhage and ulceration, and trauma from stone-like, sharply pointed concretions in the pouches have been mentioned as possible causes of hemorrhage. Mayo, Baskin, and Hagedorn [15] felt that the immediate cause of the hemorrhage was so far only speculative. They believed that rapid healing and surgery performed in the interval between attacks might explain the lack of pathologic evidence of the site of the hemorrhage.

The majority of patients with diverticula of the jejunum do not have symptoms. An atypical clinical picture may be present, however, the commonest complaints being vague pain in the abdomen, borborygmi, and flatulence, all of which usually occur after meals. Constipation, irregularity of the function of the bowels, and diarrhea have been described occasionally. An excellent résumé of the complications of diverticula of the jejunum has been presented by Benson, Dixon, and Waugh.[3] The symptoms reported by the patient will be conditioned by the location of the diverticulum and its complications. Hemorrhage into the small intestine is an unusual and serious manifestation of the disease. Melena is the commoner demonstration, although hematemesis due to reversed peristalsis may occur. Guthrie and Hughes [12] reported the incidence of bleeding from such lesions and added two cases of their own. Mayo, Baskin, and Hagedorn [15] collected 11 cases and added 3 of their own. Badenoch and Bedford [1] reported two patients with massive diverticulosis of the upper intestine who presented themselves primarily with steatorrhea and megaloblastic anemia. The authors thought that bacteria would flourish in the diverticula and infected or toxic material would spill over into the lumen of the bowel. This contamination could impair the function of the bowel and lead to failure of absorption of many substances, including fat and those necessary for normal hematopoiesis. The association of diverticulosis of the jejunum and steatorrhea or atypical megaloblastic anemia does not appear to have been noticed previously. Dick [7] reported another instance of this unusual condition. The administration of chlortetracycline produced an improvement in the diarrhea and in the general health of the patient, and the glossitis and anemia remained in remission, without further treatment with crude liver extract, for a period of eight months. It was suggested that the diverticulosis was responsible for the steatorrhea in this patient, and that the stagnation and the infection in the diverticula may have been

the most important factors in producing the small-intestinal dysfunction. Badenoch, Bedford, and Evans[2] reported observations on one survivor of the two original patients described by Badenoch and Bedford[1] and three other patients with this condition, and the authors thought that the diverticula caused the steatorrhea, which produced the megaloblastic anemia. They then found that the absorption of Co^{60}-labeled cyanobalamin U. S. P. (vitamin B_{12}) was deficient in the two patients studied in this manner but that, after a course of chlortetracycline (Aureomycin) for one week, the absorption was much increased. These observations suggested that bacterial contamination of the bowel may be responsible for the failure to absorb vitamin B_{12} in patients who have megaloblastic anemia associated with diverticulosis of the small intestine. Krevans, Conley, and Sachs[13] found a vitamin B_{12} deficiency in a patient with jejunal diverticulosis associated with a pernicious-anemia-like syndrome. A deficient absorption of Co^{60}-labeled cyanobalamin was discovered in this patient, but after the patient was given 1 gm. of chlortetracycline daily for two weeks, absorption of the cyanobalamin was increased. The cyanobalamin presumably was taken up by bacteria growing in the diverticula.

Medical treatment may afford some relief to patients with diverticulosis of the jejunum having mild symptoms. The administration of chlortetracycline produces a change in the bacteria resident in the diverticula and permits absorption of vitamin B_{12} where such absorption is deficient, as it is manifested in the patient by the presence of a megaloblastic anemia. It may be necessary to give cyanobalamin intramuscularly to these patients.

Surgical treatment is indicated for those patients having severe symptoms or complications of the disease. Visualization of the diverticula at the time of the operation may be difficult, especially when small, thin-walled, and empty sacs lie between the leaves of the mesentery. Demonstration of the diverticula will be facilitated by distending the segment with air. Resection of the involved bowel with end-to-end jejunojejunostomy generally produces relief of symptoms and appears to be the treatment of choice. A short circuiting of the involved site by enteroenterostomy was done in those patients in whom resection was not possible. In some patients with extensive diverticulosis other procedures may be indicated. Inversion of the diverticula or excision of the lesions with inversion of the stump may be done, although there is increased risk to the patient with either of these operations.

Report of a Case

A 42-year-old Negro man was admitted to the hospital for the third time on Sept. 14, 1955, with a history of tarry stools of about three days' duration. Four days prior to admission, he had severe, dull epigastric pain, which did not radiate and which occurred suddenly after a meal. Vomiting of undigested food followed, but hematemesis was not present. Weakness and dizziness were noted, but syncope did not occur. At the time of admission the epigastric pain had subsided

Fig. 1.—Scout roentgenogram of the abdomen, showing the numerous fluid levels in the left upper quadrant.

Figure 2

Fig. 2.—Gastrointestinal series, showing the diverticula of the proximal part of the jejunum.

Figure 3

Fig. 3.—Diverticula of the jejunum at time of the operation.

and only a soreness was present. An appendectomy had been done when the patient was 10 years old.

The patient was admitted to the hospital for the first time on Jan. 2, 1946, for acute bronchitis. The disease responded rapidly to treatment, and he was discharged from the hospital on Jan. 9.

The patient was admitted to the hospital for the second time on Oct. 22, 1953, for hypertensive cardiovascular disease and angina pectoris. He also complained of flatulence and epigastric pain, which were partially relieved by antacids and food. The patient had noted bright red blood in the stools for approximately one week about one month prior to admission. Roentgenograms of the abdomen following a barium meal showed numerous large diverticula in the jejunum. Later films revealed barium remaining in the diverticula after the barium meal had passed beyond the loops of the jejunum. The patient was treated successfully for his disease of the heart. The performance of further diagnostic procedures to determine the source of the blood in the stools was refused. The patient left the hospital, against medical advice, on Nov. 20.

The patient was well developed, slightly obese, and moderately ill. The temperature was 98 F, the pulse rate 100 per minute, the respirations 18 per minute, and the blood pressure 160/90. Rales were heard over the lower posterior part of the right lung field. The abdomen had a normal contour, with a healed wound in the right lower quadrant. Deep palpation in the epigastrium elicited tenderness. Rigidity of the muscles of the wall of the abdomen and palpable viscera or masses were not present. Rectal examination, including proctoscopy, was normal.

The hemoglobin was 7.4 gm. per 100 cc. and the red blood cell count 2,780,000 per cubic milli-

Fig. 4.—Diverticula of the jejunum of the resected specimen.

Fig. 5.—Bisection of a part of the resected specimen, showing the diverticula of the jejunum.

meter. The serologic test for syphilis was negative. The urine was normal. The stool was positive for occult blood.

The roentgenogram of the chest was normal. A scout roentgenogram of the abdomen with the patient in the erect view showed numerous fluid levels in the left upper quadrant (Fig. 1). Examination after a barium meal revealed diverticula in the proximal part of the jejunum (Fig. 2). The electrocardiogram demonstrated sinus tachycardia and left ventricular hypertrophy and strain.

The blood disappeared from the stool after hospitalization. Three thousand cubic centimeters of citrated whole blood was given to the patient in preparation for operation.

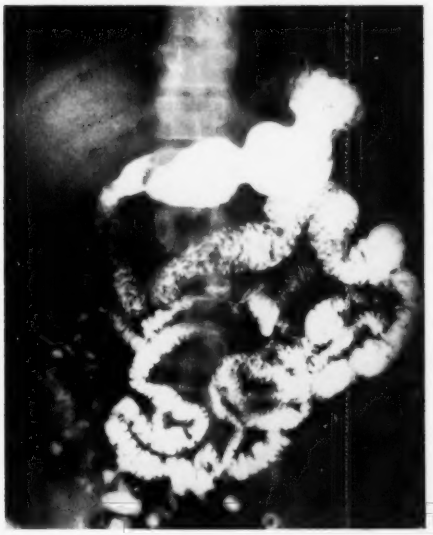
On Sept. 23, a resection of the involved area of the jejunum with an end-to-end anastomosis of the jejunum was done. Approximately 50 diverticula, about 1 to 4 cm. in diameter, were present on the mesenteric border of the jejunum, starting at a point about 10 cm. distal to the ligament of Treitz and extending distally for about 116 cm. (Fig. 3). The diverticula were pale, thin-walled, and easily collapsible (Figs. 4 and 5). Inflammation and hemorrhage were not present.

The postoperative course was uneventful. Roentgenographic examination after a barium meal, on Oct. 5, did not show any diverticula (Fig. 6). The patient was discharged from the hospital on Oct. 10.

On Jan. 10, 1956, the patient stated that occasional attacks of discomfort in the middle of the abdomen were present. He had gained 10 lb. in weight.

On April 23, the patient stated that his appetite was good and that he had gained weight. Gastrointestinal symptoms had not been present, although he had continued to have angina pectoris.

Fig. 6.—Gastrointestinal series, showing the normal remaining part of the jejunum.



Summary

A case of melena with an unusual cause, hemorrhage from diverticula of the jejunum, is reported. A successful result followed resection of the involved area of the jejunum with an end-to-end anastomosis of the jejunum.

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Blood Volume, Serum Protein, and Hematocrit Changes in Abnormal Nutritional States

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It is known that the organism attempts to sustain hemoglobin and plasma proteins at the expense of tissue proteins.[5] Furthermore, it is recognized that plasma protein concentration and hematocrit percentage may yield normal values after this mechanism has been exhausted by virtue of simultaneous alterations in the absolute values of some of the blood components. This recognition arises from ubiquitous experience with random, simultaneous determinations of absolute and relative levels of various intravascular components in subjects with nutritional deficits the types and magnitudes of which are not precisely defined. Keys et al.[1] made such observations in one type of nutritional deficit (chronic underfeeding) in human volunteers who were underfed to 76% of their initial body weight. Such studies have not been made in other types of nutritional abnormalities. Furthermore, the study cited above was not pursued into the zone of extreme undernutrition. The latter cannot, of course, be done in the human under controlled conditions. In connection with previous studies in this laboratory on the relation of various types of nutritional deficiency to surgical risk, opportunity was presented for simultaneous determinations of blood volume, arterial hematocrit, and serum protein concentration during the course of three nutritional deficiency states progressively followed to advanced degrees.

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Methods

Albino rats of the Holtzman Farms were used throughout the studies. The weight range of these animals was 200 to 250 gm. The animals were maintained in an air-conditioned laboratory, and were fed Purina Laboratory Chow and water ad libitum until the start of the experiments. Three dietary conditions were imposed: acute starvation, chronic undernutrition, and ad libitum pure cane sugar* feeding. Water was allowed ad libitum in each of the three situations, and, in the last, a multivitamin and mineral supplement† was given. The animals of this strain and size die of acute starvation in 9.5 days at 58% of their initial body weight. The dietary restriction in the chronically undernourished group was of a degree known to induce a loss to 45% of initial body weight in 100 days. Animals fed the pure sugar diet die in 127±9 days at 36% of their initial body weight. Complete details concerning the methods of feeding and weighing have been reported elsewhere.[2] Male rats were used in the serum protein concentration studies, and female rats, under parallel conditions, were used in the hematocrit and blood volume studies.

Serum Protein Concentration.—Ninety animals were divided into three groups, and each group was placed on one of the three dietary regimens described. In each group the serum protein concentration was determined just prior to imposing the dietary variable and on two subsequent occasions during the course of progressive body weight loss (specific levels are shown in Table 1). Animals were bled from the tail vein, and 0.1 ml. of separated serum was used for a quantitative biuret determination after the method of Weichselbaum.[4]

Hematocrit and Blood Volume Studies.—One hundred twenty-seven animals were divided into three groups, each group having one of the dietary regimens imposed upon it. These animals were subject to the same conditions as those in which serum protein concentration studies were made. Arterial hematocrit and total blood volume deter-

*Domino Hostess Sugar Tablets, supplied by the American Sugar Refining Company.

†Poly-Vi-Sol, supplied by Mead Johnson & Company.

TABLE 1.—*Serum Protein Concentrations at Increasing Levels of Body Weight Loss in Rats Acutely Starved, Chronically Undernourished, and Maintained on a Protein-Free Diet*

Condition	No. of Rats	Average Initial Body Weight, Gm.	Percent of Initial Body Weight	Day of Condition	Serum Protein Level, Gm/100 Ml.	*P*
Acute starvation	10	282.2	100	0	6.33±0.21	
	9	218.6	79.4	4	6.55±0.32	$0.05<P<0.1$
	7	193.3	65.0	8	6.09±0.19	$0.02<P<0.05$
Chronic undernutrition	10	262.2	100	0	6.10±0.13	
	10	201	76.8	51	6.63±0.34	$P<0.001$
	8	152.3	57.7	108	5.68±0.17	$P<0.001$
Sugar feeding	12	255.4	100	0	6.10±0.33	
	12	195.8	76.7	18	5.59±0.10	$P<0.10$
	12	141	55.2	72	4.85±0.33	$P<0.001$

minations were made initially and at varying levels of depletion in each group (Table 2). Animals used for hematocrit and blood volume determinations were bled from a cannulated carotid artery and were not further used in these experiments, owing to the amount of blood, relative to body weight, necessarily withdrawn. Total blood volumes were determined with radioactive chromium erythrocyte tagging, as previously described.[8] Blood for arterial hematocrit determinations, which were run in duplicate, was collected in capillary tubes and spun in a microcentrifuge.

Results

The serum protein concentrations in the various abnormal nutritional states are shown in Table 1. There is an increased serum protein concentration in the acutely starved and in the chronically underfed groups when determinations are made at 75%-80% of initial body weight. Thereafter there is a small, but significant, decrease in the protein concentrations in both groups such that at 35% of body weight loss the levels are below those of the controls. Serum protein concentration changes in the sugar-fed group differ from those of the former two groups in that concentration falls continuously with body weight loss and in that the magnitude of decline is considerably greater than in the former groups. This qualitative and quantitative difference is depicted in Figure 1.

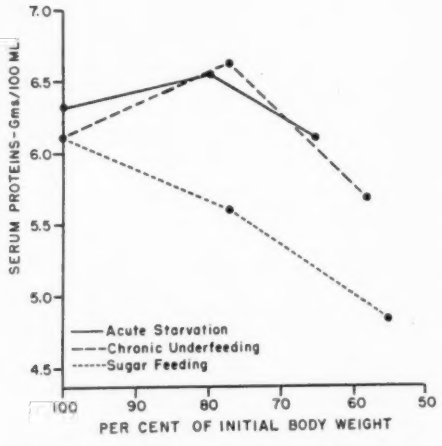

Fig. 1.—Serum protein concentration changes with increasing body weight loss in rats acutely starved, chronically undernourished, and maintained on a protein-free diet.

The blood volume observations are shown in Table 2. Arterial hematocrits in the acutely starved group undergo a continuous rise, whereas in the chronically underfed group the values are essentially stable. In the sugar-fed group there is an initial, slight rise with a marked decline appearing beyond 25% loss of body weight (Fig. 2). There is a considerable and continuous decline in total blood volume in all three groups. There is a continuous decline in plasma volume in all groups, although the magnitude of decrease is less in the sugar-fed group than in the other two groups. On the other hand, there is an insignificant change in red cell mass in the acutely starved group, whereas there is a continuous, marked decline in this component in the other two groups. Total blood volume, as percent of actual body weight, remains essentially constant in all groups at all levels of depletion.

TABLE 2.—*Blood Volume, Arterial Hematocrit, Plasma Volume, Red Cell Mass, and Blood Volume as Percent of Actual Body Weight at Increasing Levels of Body Weight Loss in Rats Acutely Starved, Chronically Undernourished, and Maintained on a Protein-Free Diet*

Condition	Percent Initial Body Weight	No. of Rats	Day of Condition	Arterial Hematocrit	Total Blood Volume, Ml.	Plasma Volume, Ml.	Red Cell Mass, Ml.	Blood Vol. as Percent Actual Body Wt.
Acute starvation	100	19	0	42.4	11.6	6.7	4.9	5.1
	99.9–90	7	1	43.8	11.4	6.5	4.9	5.7
	89.9–80	3	3	47.3	12.3	6.5	5.8	6.8
	79.9–70	4	6	50.2	8.4	4.3	4.1	5.5
	69.9–60	3	6	52.7	7.8	3.7	4.1	5.6
	59.9–50	3	9	56.0	8.0	3.5	4.5	6.3
Chronic undernutrition	100	19	0	42.4	11.6	6.7	4.9	5.1
	99.9–90	3	18	41.0	11.1	6.3	4.8	4.4
	89.9–80	5	31	39.6	8.9	5.4	3.5	4.6
	79.9–70	8	77	44.0	7.2	4.1	3.1	4.9
	69.9–60	7	103	39.5	7.1	4.3	2.8	5.2
Sugar feeding	100	11	0	42.0	11.8	6.8	5.0	4.9
	74.3	12	17	46.8	9.8	5.3	4.5	4.9
	64.2	11	45	37.8	7.4	4.6	2.8	4.4
	55.4	12	72	31.1	7.4	5.1	2.3	4.9

Table 3 is a collection of the two sets of data in the parallel groups. The behavior of the arterial hematocrit and the serum weight loss in the three abnormal nutritional states is a reflection of changes in the total components.

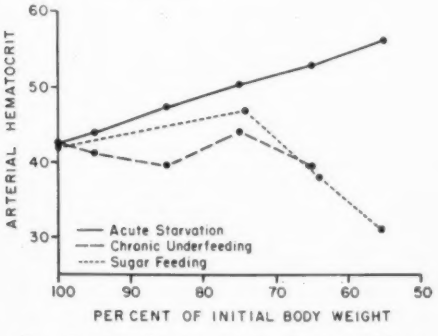

Fig. 2.—Arterial hematocrit changes with increasing body weight loss in rats acutely starved, chronically undernourished, and maintained on a protein-free diet.

The continuously rising arterial hematocrit during the course of acute starvation is seen to be resultant from a disparate reduction in red cell mass (16%) and plasma volume (43%). An approximately equivalent reduction of total proteins (48%) and plasma volume (43%) accounts for the stable serum protein concentration in this group.

The essentially stable hematocrit values during the course of chronic underfeeding rests upon a fairly equivalent diminution in red cell mass (43%) and plasma volume (36%). Also, the fairly equivalent decrease of total protein (42%) and plasma volume (36%) is the basis of the stable serum protein concentration in this nutritional defect.

The sharply falling hematocrit values in the sugar-fed group occurs in the presence of a marked disparity in red cell mass

TABLE 3.—*Total Serum Proteins at Increasing Levels of Body Weight Loss in Rats Acutely Starved, Chronically Undernourished, and Maintaining on a Protein-Free Diet*

Condition	Percent Initial Body Weight	Arterial Hematocrit	Blood Volume, Ml.	Red Cell Mass, Ml.	Plasma Volume, Ml.	Serum Protein Conc., Gm/100 Ml.	Total Serum Protein, Gm.
Acute starvation	100	42.4	11.6	4.9	6.7	6.33	0.42
	89.9–80	47.3	12.3	5.8	6.5	6.55	0.43
	69.9–60	52.7	7.8	4.1	3.7	6.09	0.22
Chronic undernutrition	100	42.4	11.6	4.9	6.7	6.10	0.41
	79.9–70	44.0	7.2	3.1	4.1	6.63	0.27
	69.9–58	39.5	7.1	2.8	4.3	5.68	0.24
Sugar feeding	100	42.0	11.8	5.0	6.8	6.10	0.41
	75	46.8	9.8	4.5	5.3	5.59	0.30
	55	31.1	7.4	2.3	5.1	4.85	0.25

(54%) and plasma volume reduction (25%). The significant fall in serum protein concentration in this group correlates with a significant disparity in decline of total proteins (39%) and plasma volume (25%).

Comment

It is interesting to note that the total serum proteins diminished in about the same magnitude in acute starvation, in chronic underfeeding, and in pure carbohydrate feeding. The percent disappearance of serum proteins was equivalent in acutely starved animals at 60%-70% of initial body weight, in chronically undernourished animals at a little over 60% of initial body weight, and in carbohydrate-fed animals at 55% of initial body weight. Protein intake in the acutely starved and in the sugar-fed groups was, of course, nil. In the chronically underfed group the daily protein intake fell progressively from 2.8 to 1.4 gm. as intake was adjusted to produce a linear fall in body weight to 55% of the initial level in 100 days. This compares with a daily protein intake of 3.7 gm. in animals fed standard laboratory ration ad libitum.

In acute starvation and in chronic underfeeding there is a slight, gradual rise in serum protein concentration, which reaches a peak when about 25% of initial body weight is lost. Thereafter there is a decline, so that at 35% of initial body weight the concentrations are at initial levels. This is paralleled by a progressive, near-equivalent, diminution of plasma volume and total circulating proteins. In the sugar-fed group there was a linear fall in serum protein concentration, which was paralleled by progressive declines in total serum proteins and plasma volume, the latter being of greater magnitude than the former.

Hematocrit values showed continued increase during acute starvation, during which time there occurred a greater reduction in red cell mass than in plasma volume. In chronic underfeeding the hematocrit level was fairly stable, as can be seen to be premised upon an approximately equivalent reduction of red cell mass and plasma volume. In the sugar-fed group the hematocrit values fell progressively, accompanied by a considerably greater decrease in red cell mass than in plasma volume.

Relative blood volume (blood volume expressed as percent of actual body weight) in each of the three nutritional deficiency states studied remained essentially constant. In chronic underfeeding of human volunteers to 74% of their initial body weight, Keys et al. reported a progressive increase in relative plasma volume and, to a less degree, blood volume.[1] T-1824 (Evans blue) was used to determine plasma volume in Keys' study. Cr^{51}-tagged erythrocytes were used to determine blood volume in the present studies. This laboratory has previously reported that relative blood volume increases when determined with T-1824, whereas it remains stable when determined with Cr^{51}, in acutely starved and chronically undernourished albino rats.[3]

Summary

Blood volume, serum protein concentration, and arterial hematocrit determinations were made during progressive nutritional deficiencies in acutely starved and chronically undernourished rats and in rats maintained on a protein-free (pure carbohydrate) diet.

There is an appreciable, continuous decline in blood volume in all three types of deficiency. However, blood volume relative to actual body weight remains essentially stable throughout.

Serum protein concentration declines progressively in animals maintained on the protein-free diet, but changes little in acutely starved and chronically undernourished animals.

The arterial hematocrit rises progressively in acute starvation, remains essentially stable in chronic undernutrition, and

in animals fed a protein-free diet declines rapidly beyond 25% body weight loss.

Changes in the total vascular components, upon which the behavior of serum protein concentration and hematocrit values rest, are described.

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Treatment of Experimental Strangulation Obstruction

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The search for more efficacious methods with which to combat the deleterious effects of strangulated intestinal obstruction is justified by the continuing high mortality rate of this condition. The toxicity of peritoneal fluid resulting from strangulation obstruction is now well established. Previous experiments have shown that irrigation of the peritoneal cavity of normal dogs increased their chances for survival following exposure to peritoneal fluid of animals dying of strangulation obstruction.[3] Evidence was also obtained which indicated that the combination of irrigation and antibiotics was more beneficial than either method alone.[2] These animals, of course, were not subjected to the harmful effects of fluid, electrolyte, and blood loss, as well as complications incident to resection and anastomosis of intestine. The purpose of the following experiments was to establish the value of peritoneal lavage and parenteral antibiotics in the treatment of animals with strangulation obstruction.

Materials and Methods

Forty adult mongrel dogs, weighing between 8 and 18 kg., were used in these experiments. Food and water were withheld on the day of operation, but were offered to all animals during the postoperative period. Anesthesia was induced and maintained by fractional intravenous doses of pentobarbital (Nembutal). Utilizing sterile technique, the lower ileum was exposed through a midline abdominal incision. The venous supply to a 10 cm. segment of ileum was ligated, after which encircling ties of umbilical tape were placed at each extremity. In order to maintain strict control of the time of exposure to the toxic fluid, the resulting closed loop of strangulated bowel was placed in a plastic bag and secured by two umbilical-tape ties. Polyethylene bags with a volume of 1 qt. (1 liter) were used. The bag containing strangulated bowel was returned to the abdominal cavity, after which the wound was closed. Twenty-four hours later the abdominal cavity was reopened for withdrawal of the plastic bag and its contents. Normal bowel above and below the site of obstruction, along with the mesentery of the gangrenous bowel, was divided so that the bag and its contents were completely separated from the animal. Intestinal continuity was restored by a two-layer, end-to-end anastomosis (Fig. 1). Each animal was given an intraperitoneal injection of his own fluid in the amount of 3 cc. per kilogram of body weight. After completion of the treatment given the various groups, the abdominal wound was closed, and all animals were observed for survival time.

Group 1 (eight animals).—The strangulation obstruction fluid was not removed from the peritoneal cavity of the animals comprising this group.

Group 2 (nine animals).—After an interval of five minutes the fluid was aspirated from the peritoneal cavity.

Group 3 (nine animals).—Aspiration of the fluid after a five-minute interval was followed by thorough irrigation of the peritoneal cavity with 1 liter of isotonic saline.

Group 4 (six animals).—The fluid was not removed from the peritoneal cavity. Each animal received an intramuscular injection of 600,000 units of penicillin at the time of injection of the fluid. A similar injection of penicillin was given four hours later.

Group 5 (eight animals).—After exposure to the fluid for five minutes the peritoneal cavity was irrigated with 1 liter of isotonic saline. An intramuscular injection of 600,000 units of penicillin was given at the time of exposure to the fluid.

Results

Following ligation of the venous supply each altered segment of bowel turned dark rapidly. Within 15 minutes it became moderately distended with fluid. After 25 minutes several cubic centimeters of yellow fluid, resembling blood plasma, could be

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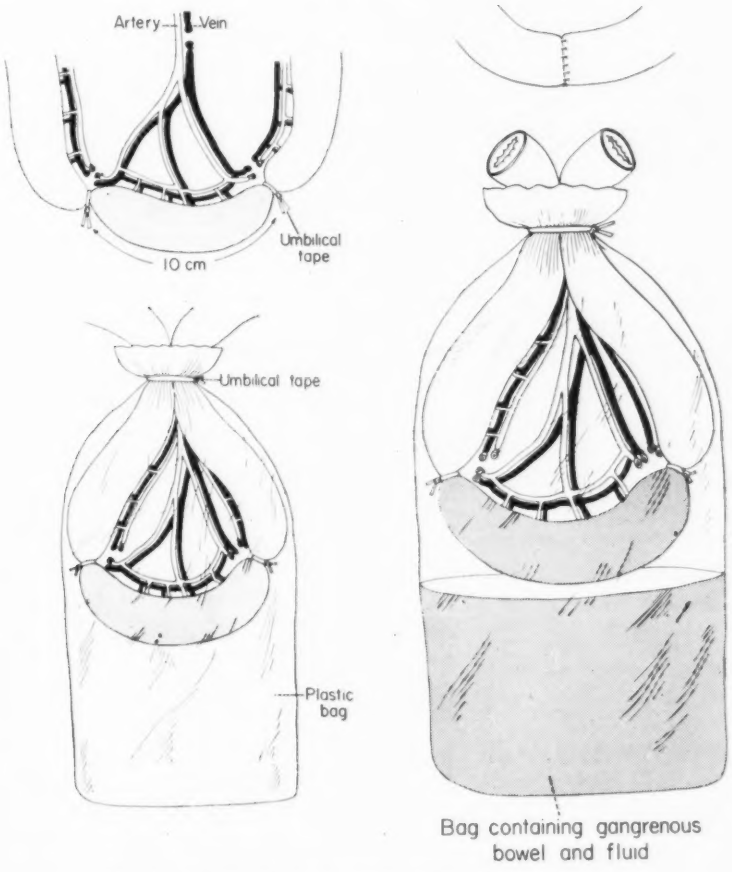

Fig. 1.—Method of strangulating ileum and collecting fluid.

seen in the plastic bag. Most animals moved around their cages in a normal manner after recovery from the first anesthetic. At the second operation the peritoneal cavity of each animal revealed varying amounts of cloudy fluid. The plastic bags contained dark, foul fluid, in amounts ranging from 85 to 250 cc. The enclosed intestinal wall was black and thick in appearance. Its lumen contained fluid similar in appearance to that found in the plastic bags.

TABLE 1.—*Results in Animals in Which Fluid Was Not Removed from Peritoneal Cavity*

Dog No.	Amount of Fluid Produced, Cc.	Weight, Kg.	Amount of Fluid Injected, Cc.	Lived, Hr.
126	200	14	40	7
1	85	9	27	4
177	125	12	36	14
199	210	13	39	7
112	140	18	54	5
100	60	13	39	5
131	128	12	36	7
120		11	33	12

Group 1.—None of the animals recovered in this group, and only one could be aroused after the second anesthetic. Survival time ranged from 5 to 14 hours, with a mean value of 7.6 hours (Table 1).

Group 2.—The results following aspiration of the fluid after exposure for five minutes were no better than where the fluid was not removed. The mean survival time was 6.7 hours, with a range of 3 to 12 hours (Table 2).

TABLE 2.—*Results in Animals in Which Fluid Was Aspirated from Peritoneal Cavity After Five Minutes*

Dog No.	Weight, Kg.	Amount of Fluid Injected, Cc.	Lived, Hr.
90	8	24	6
27	14	42	3
158	13	39	7
161	12	36	3
118	12	36	10
110	12	36	12
19	12	36	7
135	13	39	6
115	10	30	7

TABLE 3.—*Results in Animals Whose Peritoneal Cavity Irrigated Five Minutes After Injection of Fluid*

Dog No.	Weight, Kg.	Amount of Fluid Injected, Cc.	Lived, Hr.
132	13	39	12
46	16	48	72
162	14	42	19
93	11	33	4
198	14	42	10
29	13	39	48
115	9	27	12
94	13	39	13

Group 3.—The mean survival time in this group subjected to irrigation of the peritoneal cavity was extended to 23 hours. It ranged from 4 to 72 hours (Table 3).

Group 4.—The administration of penicillin without removal of fluid resulted in a mean survival time of 13 hours. The range was 3 to 24 hours (Table 4).

TABLE 4.—*Results in Animals Given Penicillin Without Removal of Peritoneal Fluid*

Dog No.	Weight, Kg.	Amount of Fluid Injected, Cc.	Lived, Hr.
140	14	42	18
198	8	24	3
100	14	42	5
153	12	36	10
135	14	42	12
111	14	42	18
152	9	27	24

Group 5.—The combination of penicillin and irrigation resulted in complete recovery of five animals (60%). The mean survival time for the remainder of this group was 27 hours, with a range of 8 to 56 hours (Table 5) (Fig. 2).

TABLE 5.—*Results in Animals Which Received Penicillin and Irrigation of Peritoneal Cavity Five Minutes After Injection of Fluid*

Dog No.	Weight, Kg.	Amount of Fluid Given, Cc.	Lived, Hr.
93	12	36	Recovered
195	12	36	56
119	12	36	8
47	10	30	16
43	13	39	Recovered
82	9	27	Recovered
196	14	42	Recovered
128	9	27	Recovered

Comment

The precise nature of the material responsible for the toxicity of strangulation obstruction fluid has not been established. The lethal characteristics of the fluid are eliminated by heat.[5] Considerable evidence has been accumulated which indicates that bacteria play a significant, if not dominant, role in strangulation obstruction.[8] The introduction of neomycin into the lumen of a closed loop of strangulated bowel resulted in the accumulation of nontoxic peritoneal fluid.[1] The alpha toxin of the Clostridium welchii has been identified in the peritoneal fluid of experimental animals with gangrenous bowel.[9] We have been able to eliminate the toxic characteristics of strangulation obstruction fluid by high-speed centrifugation (17,000 rpm).[6] Moreover, the raw fluid was no longer toxic after having been passed through a Seitz filter. Administration of toxic peritoneal fluid of strangulation obstruction is always followed by a leukopenia in the recipient animals, but when the alpha toxin of the Clostrid-

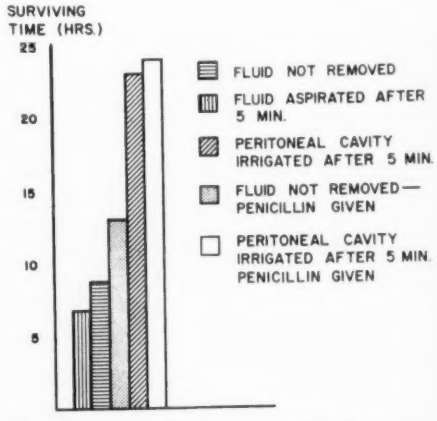

Fig. 2.—Comparison of survival time in animals which failed to recover after exposure to their own strangulation obstruction fluid.

ium welchii was given to normal animals, a leukocytosis followed.[1] These findings strongly question the role of exotoxins in the lethal issue of strangulation obstruction.

Following strangulation of the short closed loop segment of ileum experimental animals pursue an uneventful course for about 20 hours. During this time the altered bowel becomes dark and thick-walled, and the lumen is tightly distended by fluid and blood elements. Micro-organisms inside the lumen multiply rapidly, so that the enclosed fluid is teeming with myriads of bacterial cells. As soon as the integrity of the bowel wall is compromised, this highly toxic material floods the peritoneal cavity. This is followed by rapid deterioration, and the animal is usually dead within four to eight hours.

In treating this condition, it seems logical to assume that complete removal of this toxic material is of great importance in increasing the chances for recovery. This is supported by the fact that longer survival times were obtained in this study, as well as in previous experiments when irrigation of the peritoneal cavity was substituted for simple aspiration of the fluid. Burnett et al. have recorded both experimental and clinical data which support the efficacy of peritoneal lavage in treating peritonitis.[3] When normal animals were given fluid from other animals dying of strangulation obstruction, 100% recovered after irrigation and antibiotic therapy if the exposure time was 20 minutes or less.[2] In dogs with strangulation obstruction treated in the same manner the survival rate was 60% (Fig. 3). In the latter animals the fluid was more concentrated because it was collected in a plastic bag directly from the intestine and was not diluted by peritoneal fluids. This, along with other obvious differences, accounts for the higher survival rate in normal animals which were given peritoneal fluid recovered from animals dying of strangulation obstruction.

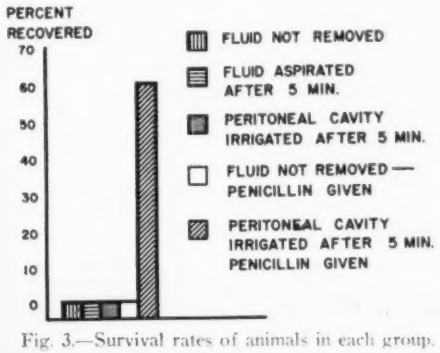

Fig. 3.—Survival rates of animals in each group.

Summary and Conclusion

The mean survival time of animals which were exposed to their own strangulation fluid was 7.6 hours.

Survival time of animals from which the fluid was removed after five minutes was no better than that of the first group.

Animals who received irrigation of the peritoneal cavity lived 23 hours (mean value).

The use of parenteral antibiotics alone resulted in a mean survival time of 13 hours.

When irrigation of the peritoneal cavity was combined with parenteral penicillin, five (60%) of the animals recovered.

Irrigation of the peritoneal cavity combined with parenteral penicillin is of value in the treatment of experimental strangulation obstruction.

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Jejunogastric Intussusception—an Unusual Complication of Gastric Surgery

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Jejunogastric intussusception is a serious complication of gastric surgery, which, although rare and little known, may be easily diagnosed if the surgeon is aware of the possibility. It is the purpose of this article to report a case seen recently by us and to review briefly the recent literature on this unusual complication of gastric surgery.

There are several excellent reviews of the subject. The first comprehensive review was made in 1933 by Bettman and Baldwin,[1] in which they summarized the clinical findings in 33 cases. Irons and Lipin,[2] in a more recent survey (1955), reviewed 99 published cases, to which they added 1, making the total 100. The majority of the cases have been reported in European literature; only 10 cases of this condition have been reported in this country up to the present time.[3] However, the majority of the cases occurred after gastroenterostomy.

The first gastroenterostomy was performed in 1881, but the first case of jejunogastric intussusception was not reported until 1914, by Bozzi.[4] In 1924, von Brunn published the first roentgenographic findings of the condition.[5] The first case following subtotal gastrectomy was reported by McNamara in 1944,[6] the original operation having been done for a duodenal ulcer. Lavadia, Haynes, and De Bakey,[7] in 1953, reported the first case following partial gastrectomy for carcinoma of the stomach. In 1955 Irons and Lipin[2] reported the first case following gastroenterostomy combined with vagotomy.

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Aleman,[8] in 1948, classified the types of jejunogastric intussusception. Class I is an intussusception of the afferent loop of the jejunum into the stomach lumen. Class II, which constitutes 75% of the cases, is an intussusception of the efferent loop. Class III, relatively rare, consists of a prolapse of both loops through the gastroenterostomy stoma.

Evidently, there is still little known about jejunogastric intussusception among members of the medical profession in general, as shown by the delay in diagnosis and surgical treatment. Chesterman,[9] in 1933, reported the first correct preoperative diagnosis. By 1944 there had only been four cases diagnosed correctly prior to operation. In nearly 30% of the reported cases the diagnosis was not made until autopsy; therefore, one must consider this condition when planning the course of treatment for a patient who has acute symptoms referable to the upper gastrointestinal tract following gastric surgery. Since this type of intussusception is rare, the patient vomiting blood will frequently be treated the first 24 to 48 hours conservatively, with the tentative diagnosis of recurrent or anastomotic ulcer.

The mortality rate in patients operated upon less than 48 hours after the onset of symptoms was only 10.5%, and more than 48 hours after the onset the mortality rate was 53.8% in the cases reviewed by Foster.[10]

The etiology of retrograde jejunogastric intussusception is unknown. Most authors feel that it is due to a retrograde peristalsis which is secondary to some functional disturbance rather than to a mechanical

disturbance. Some authors have stressed the following factors as causes of jejunogastric intussusception: hyperacidity, hypotonia of the gastric wall, a large stoma, and sudden increase in intra-abdominal pressure; however, none of these factors have occurred consistently in the cases reviewed.

Bettman and Baldwin[1] found that the interval between original gastroenterostomy and the development of this complication ranges from 6 days to 16 years. The size of the stoma varied from 2 to 5 cm. in diameter, and the length of the invaginated bowel from 5 cm. to 2 meters. The ages of the patients ranged from 21 to 75 years.

The clinical picture varied in the reported cases but is usually characterized by the sudden onset of severe epigastric pain, followed shortly by vomiting. The pain is intermittent and colicky in character, and as the condition progresses, the pain increases in frequency and severity. The vomiting is of an intermittent, frequent, projectile type. The vomitus, in the beginning, consists of clear gastric fluid but later becomes reddish-brown, as the mucosa of jejunum becomes ischemic. The physical findings are also variable and may consist of no more than some upper abdominal tenderness in the early case, or marked tenderness and border-line rigidity in the late case. A palpable epigastric mass has been present in 10%-15% of the reported cases.[11] A palpable mass may be difficult to ascertain following subtotal gastrectomy because the gastroenterostomy stoma is concealed by the costal margin. The diagnosis should always be seriously considered in patients with hematemesis following gastric surgery whether with or without pain, or with or without a palpable mass, but almost certainly if accompanied with both pain and a mass. There are a few case reports of chronic and intermittently recurrent type of jejunogastric intussusception which is much milder than the acute type. To make the diagnosis, it is necessary to have roentgenograms while the symptoms are present. Details regarding this type of intermittent intussusception have been reported in detail by Butler, Woolley, and Burton.[12]

Aleman[8] emphasized that the striated filling defect in the stomach is pathognomonic of jejunogastric intussusception. A polypoid mass is visible within the stomach, with its base at the site of the gastroenterostomy stoma. The size of the mass varies with the amount of jejunum intussuscepted into the stomach. There are parallel lines, spirals, or concentric circles across the mass, due to collection of barium between the vulvae conniventes.

Early surgical reduction is indicated in the acute form. Bettman and Baldwin[1] found that reduction alone is adequate in the majority of cases if the affected bowel is viable. The operative procedure will vary with the severity of the condition found on exploration. There have been no reported cases having a recurrence of the jejunogastric intussusception following surgical reduction.

Report of a Case

On Jan. 26, 1958, a 74-year-old white man was admitted to the hospital with a history of severe, intermittent upper abdominal pain, of three days' duration. The pain was sudden in onset and of a cramping and colicky character. It was first noticed when the patient bent over to tie his shoes. He vomited once the day before admission, and on the day of admission he vomited three times. The vomitus was clear. The morning after admission Wangensteen suction yielded a large quantity of brownish, foul-smelling drainage. This drainage persisted until the time of surgery, 72 hours following admission.

The patient had had a gastric resection seven years prior to this admission, following his second episode of hemorrhage from an ulcer on the lesser curvature of the stomach. He had been asymptomatic with respect to his stomach since that time except for a gradual weight loss.

Examination revealed an elderly, emaciated white man, who appeared acutely ill and dehydrated. There were marked epigastric tenderness and some guarding. However, there was no rigidity or palpable epigastric masses. The tentative diagnosis on admission was marginal ulcer or acute pancreatitis.

Preoperative x-ray showing jejunogastric intussusception.

The laboratory work on admission was normal except for leukocytosis. The following morning the serum electrolytes were compatible with hypokalemic metabolic alkalosis, which was corrected with intravenous potassium chloride. The tubeless gastric analysis following surgery was indicative of achlorhydria.

The plain x-ray films of the abdomen were reported as normal. The barium studies were reported as follows: "The distal half of the stomach has been resected. There is a large polypoid tumor mass in the stomach, which measures 6 cm. in diameter. Would like to re-x-ray to confirm." The report the following day was as follows: "The same findings as before, but the polypoid mass in the pars media just above the gastroenterostomy stoma is an intussusception of the jejunum into the stomach" (Figure).

Immediately following x-ray examination the patient was taken to surgery. At operation the stomach was seen to be filled with a large, doughy mass. Close examination of the gastroenterostomy stoma revealed a jejunogastric intussusception involving the efferent loop of the jejunum. The intussusception was reduced with difficulty, and the estimated length of jejunum involved was approximately 20 in. (51 cm.). Eight inches (20 cm.) of the intussuscepted jejunum was gangrenous. A resection was done, with an end-to-end anastomosis.

The immediate postoperative period was uneventful except for a low serum sodium of 131 mEq/L. and chloride of 95 mEq/L. on the third day. The following day the patient appeared dehydrated and slightly confused. A repeat of the serum electrolyte determination revealed a serum sodium of 123 mEq/L. and a serum chloride of 90 mEq/L. This imbalance was corrected promptly with intravenous hypertonic saline. The patient was discharged on the 10th postoperative day in excellent condition.

Summary

The recent literature regarding jejunogastric intussusception following gastric surgery is reviewed, and the etiology, pathology, and clinical pictures are discussed. The case presented is typical of those found in the literature and serves to emphasize that this condition must be considered when treating a patient who presents the following picture: intermittent epigastric pain, nausea and vomiting followed by hematemesis, and a palpable mass following gastric surgery. The condition has a 100% mortality if not diagnosed and treated surgically.

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Experience with Bleeding Peptic Ulcer in a Community Hospital

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The repeated attention in the medical literature to the problem of bleeding peptic ulcer surely implies that this is an important subject to every physician, and that there is more to be learned about it. Our purpose in this discussion is to present for critical evaluation the experience of the attending staff of a community hospital with bleeding-ulcer patients over a period of seven years. We would also like to present our attitude toward the management of these cases and to look into the significance of certain aspects of bleeding ulcers by an analysis of those factors in the cases reviewed.

The material studied represents the cases of bleeding ulcer which have been treated in the Memorial Hospital, Worcester, Mass., from October, 1949, through September, 1956. These cases have been under the care of all of the members of our medical and surgical staff and include quite a number of service cases under the direct supervision of the resident staff, with the help of the attending staff. It becomes obvious, therefore, that the mode of treatment is subject to some variation by virtue of the number of physicians involved. We feel, however, that the attitude of all these physicians toward the bleeding ulcer represents a reasonably unified attempt at conservative medical management, with surgical intervention only as necessary.

Criteria for Cases

Approximately 200 cases were reviewed, many of which were discarded because the recorded data did not appear adequately to substantiate the diagnosis of upper gastrointestinal bleeding. The review covers 143 cases (124 patients) in which there is essentially incontrovertible evidence of upper G. I. bleeding and in which other causes have been ruled out. Some cases have had to be labeled "suspected cases," as explained below, but all have been critically reviewed and an honest evaluation attempted. In the course of this review we found 10 cases of upper G. I. bleeding of some proved cause other than ulcer, as shown in Table 1.

TABLE 1.—*Other Sources of Bleeding*

Esophageal varices	4
Carcinoma of stomach	1
Hypertrophic gastritis	1
Meckel's diverticulum with bleeding ulcer of ileum	2 *
Multiple myeloma	1
Ruptured cirsoid aneurysm of gastric-wall artery without ulcerations	1

* Two admissions of same patient.

We have classified our bleeding ulcers into three groups: (1) proved ulcer, 82 cases (ulcer crater demonstrated by x-ray or by pathological examination); (2) presumed ulcer, 34 cases (these include cases with x-ray deformity without a crater, history of a proved previous ulcer, or subsequent ulcer), and (3) suspected ulcer, 27 cases (these represent the least well-documented cases and include those in which there is no definite proof of ulcer but in which other causes have been ruled out and clinical presumption seems justified).

Incidence

As shown in Table 2, we have divided our cases according to sex (male and female) and age (by decades). It will be noted that the ratio of male to female

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TABLE 2.—*Sex and Age Incidence*

Age	Teens	20's	30's	40's	50's	60's	70's	80's	90's	Total
Male	2	3	5	10	25	30	29	7	0	111
Female	0	2	3	5	8	6	4	3	1	32
Total	2	5	8	15	33	36	33	10	1	143

patients was 3.5:1 and that 71% of all cases fell in the fifth, sixth, and seventh decades, with approximately similar incidences in these decades for the male patients. There would appear to be too few female patients for such a breakdown of figures to be of any significance, but the spread seems to be quite similar to that of the male patients.

One has heard so frequently about the noticeable grouping of ulcer complications in the spring and fall that it is interesting to find that this was not particularly borne out, as shown in Table 3. It will be noted

TABLE 3.—*Seasonal Incidence*

Spring	43
Summer	28
Fall	32
Winter	40

that the greatest frequency occurred during the winter and spring, with a noticeable decrease during the summer, but that there was no preponderant grouping in any one or two seasons.

Among our patients there were only 82 who had definitely proved ulcers; thus, in only this group were we able to determine the incidence of ulcer location. As shown in Table 4, the location is very much as would be expected. The three ulcers described as "pyloric" were located in the pyloric ring, and thus did not fall definitely into either the gastric or the duodenal group.

TABLE 4.—*Location of Proved Ulcers*

Duodenal	58
Gastric	17
Marginal	4
Pyloric	3
Total	82

Management

Obviously, in a group of patients handled by so many different physicians there has been some variation in management. What we are presenting here is our personal preference. The management has, however, become more or less standardized among many of the physicians who have handled the cases under discussion.

Following an initial careful general evaluation of the patient, an immediate attempt is made to determine and rapidly replace the amount of blood that may have been lost up to that time. This procedure must depend, of course, a great deal on the clinical impression of the patient, together with the history of bloody vomitus, duration of bleeding evidence, especially as to the color of stool, and the presence of signs of shock, either at the time of admission or as evidenced by previous syncope, etc. The initial hemoglobin and hematocrit determination is, of course, notoriously misleading in many instances, particularly when bleeding has been sudden and copious, without adequate time having elapsed for restoration of blood volume with consequent dilution. This is documented in an interesting way in the evaluation of patients who have fainted prior to admission (Table 9).

A Levin tube is immediately passed into the stomach and the contents aspirated. This tube is then left indwelling without suction, and repeated aspirations are carried out at one-half- to one-hour intervals. We feel that this measure is of great benefit in following the course of the patient's bleeding and in alerting us promptly to recurrent bleeding, which is recognized to be of rather dire significance in many instances.

As soon as feasible after admission, consultation is obtained with an internist, or, in the case of a patient admitted to the medical department, with a surgeon. We feel that a medical-surgical team effort is of great importance in caring properly for these patients. In addition to help in management of the bleeding problem, an internist is of great help in evaluating the patient's cardiopulmonary status and all of the other factors influencing determination of the type of management. The surgeon, with his familiarity with bleeding patients and his experience in management of hemorrhage and determination of the need and timing for surgery, should certainly have an opportunity to follow these patients from the earliest possible time.

Transfusion of whole blood is started *immediately* on all patients who are thought to have lost as much as 500 cc. of blood. With the total blood loss estimated, it is planned to replace this volume immediately. In the case of severe, profuse hemorrhage, transfusions of blood are given simultaneously in the two arms, cut-downs being utilized if necessary. Often this blood is given under pressure when signs of shock are present. It is very important that 18-gauge needles be used. Excellent cooperation with the blood-bank personnel must be maintatined because of the frequent need of very large volumes of blood in these cases. This need may well become apparent during the night, or at other times when blood donors are not readily available. With this in mind, we always plan to have at least 5 pints (2500 cc.) of blood cross matched and available in the blood bank, in addition to the blood which we feel must be given to replace the present deficit. This will also allow us adequate blood on hand for surgery if it becomes necessary. In the early restoration of blood volume, we continue the transfusion until the hemoglobin reaches a level of 12 gm. and then, as the patient is followed further, attempt to keep the hemoglobin at that level.

During the period of close observation, which, of course, must continue until all signs of bleeding have been absent for several days, we have a hemoglobin and hematocrit determination every four to eight hours. The patient's vital signs are determined and recorded at one-half- to one-hour intervals, or more frequently if shock impends. The patient is kept under constant moderate sedation, and intramuscular propantheline (Pro-Banthine) is given every six hours. The patient is given 1 to 2 oz. (30 to 60 cc.) of milk by mouth each hour and ½ oz. (15 cc.) of Gelusil (an antacid containing 7½ grains [0.488 gm.] of magnesium trisilicate and 4 grains [0.26 gm.] of aluminum hydroxide per teaspoon [4 cc.]) each hour. Needless to say, the aspirations of the Levin tube must be timed so that these feedings will not immediately be withdrawn from the stomach. Other routine laboratory work is ordered for the earliest convenient time.

We feel very strongly that a barium-swallow study should be done at the earliest convenient time when the patient is out of shock and can be moved about with safety, even though bleeding may still be active. Usually this is done on the day of admission or on the following morning. The Levin tube is usually removed temporarily for this determination, since the radiologist is able to give us more information concerning the presence of varices without the tube in place. At the time of the barium-swallow study a routine chest x-ray is also obtained, since the patient is often in the elderly age group and valuable information may be obtained from this procedure.

We have found it very helpful to have a one-sheet chart kept in the patient's record during this period of close observation on which are listed the vital signs, the hemoglobin and hematocrit determinations, the blood given, and the amount and character of fluid obtained on Levin tube aspirations. Thus, on one easily read sheet are included the data which most help us in determining the status of the patient.

TABLE 5.—*X-Ray Findings*

Ulcer Proved by Surgery or Autopsy	
X-ray reveals crater	18
X-ray reveals deformity	6
X-ray negative	0
No x-ray taken	17
Total	41
Ulcer Proved or Presumed Clinically	
X-ray reveals crater	54
X-ray reveals deformity	35
X-ray reveals hiatus hernia only	3
X-ray reveals gastroenterostomy only	4
X-ray negative	20
No x-ray	27
Total	143

During the seven-year period of this study several patients were given absorbable gelatin sponge U. S. P. (Gelfoam) and thrombin in various combinations, to be swallowed by mouth or to be instilled through the Levin tube. Our clinical impression has been that this is of no particular benefit. In reviewing the records of our cases, a similar impression was obtained. There are certainly too few of these cases included for a statistical analysis of this measure to be of any significance.

In Table 5 we have shown the correlation between the clinical and pathological data and the findings by x-ray. As will be seen, a very high proportion (116 of 143) of our patients had x-rays taken.

Of the 116 cases in which x-rays were obtained, the findings were entirely negative in only 20. Cases with any deviation from normal, such as hiatus hernia or minimal deformity, were excluded from this small group. In only two of these cases with negative x-rays was a diagnosis of ulcer verified by some other means. In one case bleeding occurred again 18 months later, at which time an ulcer was demonstrated by x-ray. In a second case a gastric ulcer had been demonstrated radiographically prior to this bleeding admission. One of these 20 patients died, and autopsy was entirely negative for the cause of bleeding, in spite of massive upper intestinal hemorrhage. It was of interest that 5 of these 20 patients with negative x-rays were repeated bleeders, with other bleeding episodes prior to or subsequent to this bleeding admission. These particular patients are of great interest to us and are discussed further below.

It is worthy of note that of the 24 cases in which ulcer was proved either at surgery or at autopsy, and in which a barium-swallow study was done, an x-ray crater was demonstrated in 18 and a deformity was described in the remaining 6. Thus, in all these cases the diagnosis was made by the radiologist, so that the source of bleeding in these cases was immediately known. Surely this demonstrated the value of an early barium swallow in these bleeding cases. Indeed, of all the 116 presumed bleeding-ulcer patients studied roentgenographically, only 20 had negative x-rays.

Indications for Surgery

It is obviously not within the scope of this paper to go into great detail on the very complicated subject of determining the indications for surgery in cases of bleeding ulcer. It might be pertinent to point out, however, that we have generally divided these indications into three main groups for purposes of clarification.

1. The patient with massive exsanguinating hemorrhage obviously must be operated upon very promptly. These cases are usually obvious when first seen, and very rapid blood replacement is immediately instituted and the patient brought to surgery without any prolonged attempt to restore the blood volume, which obviously cannot be restored prior to control of the large bleeding point, usually involving the superior pancreaticoduodenal or the right gastric artery.

2. The patient with repeated hemorrhage is certainly a candidate for surgery. We have all been impressed with the significance of sudden reappearance of massive bleeding in a patient as indicating inability of the patient to control adequately the bleeding point, which is surely of considerable size.

3. The patient with a continuing hemorrhage must obviously be operated upon.

This type of hemorrhage is certainly the most difficult to recognize. The dire consequence of waiting too long in cases of this type is known to all of us. There are many aspects of the clinical picture that help in the decision to operate, and they are difficult to define. Generally speaking, the patient who, after restoration of blood volume, requires more than 500 cc. of blood every six hours to maintain a normal hemoglobin level beyond 24 hours is likely to fall into this group.

Many surgeons feel that a patient who enters the hospital with a bleeding ulcer, who is in good general condition, but who is a strong candidate for elective surgical treatment of his ulcer on the basis of other factors, should be subjected to immediate surgery. It is argued that the risk is no greater in this patient than a regular elective operation, and that the possible hazards of the bleeding are avoided in him by prompt surgery. This point is surely a debatable one, and it is our personal feeling that a patient who has had intestinal bleeding of any magnitude is *not* truly as good a risk for elective surgery. We would prefer to treat this patient conservatively and perhaps have him stay in for an elective resection 7 to 10 days after the bleeding episode.

Among the 143 cases studied, 37 (26%) were operated on. In 18 of these, however, the operation was elective, and was done later, during the hospitalization, after the bleeding had been controlled. Thus, we found the need for emergency surgery in 13% of our cases. As will be seen in Table 6, our surgical patients were divided into three groups, based on the interval between admission and surgery, 14 patients being operated on during the first 48 hours, 9 between the second and the seventh day, and 14 after the first week of hospitalization. The five patients with emergency surgery operated upon after the first 48 hours represent, of course, those patients that began to bleed again massively after initial control of the hemorrhage.

TABLE 6.—*Mortality Figures*

	Cases	Deaths	Percentage
No surgery	106	10	9.4
All surgical	37	6	16.3
Emergency surgery	19	5	26.3
Elective surgery	18	1	5.5
No surgery plus elective surgery	124	11	8.9
Surgery—1st 48 hr.	14	5	35.7
Surgery 2-7 days	9	0	0
Surgery after 7 days	14	1	7.1
All cases	143	16	11.2

TABLE 7.—*Severity of Hemorrhage—Blood Replacement*

	1st 24 Hr.		Total	
Mild (500 cc.)	51	36%	25	17%
Moderate (500–1500 cc.)	50	35%	35	24%
Severe (1500 cc.)	42	29%	83	58%

Severity of Hemorrhage

Assuming that blood replacement was proper and adequate, the best basis for evaluation of these cases as to severity of hemorrhage would appear to be the amount of blood replacement given. As seen in Table 7, we have considered that a mild hemorrhage represents blood replacement of 500 cc. or less, a moderate hemorrhage replacement of 500 to 1500 cc., and a severe hemorrhage replacement in excess of 1500 cc. We have evaluated our cases on this basis, with respect both to the blood replacement during the first 24 hours and to the total blood replacement. It would appear that the latter figure is more reliable, for many reasons. It includes, of course, blood given during surgery in the surgical cases, but, by and large, these figures do represent the severe hemorrhages, so that the over-all figures should not be thus affected. From these figures it becomes immediately apparent that severe hemorrhage alone is not an indication for surgery, since nearly 60% of our cases represented severe hemorrhage and yet only 13% were subjected to emergency surgery. The small number of cases classified as mild hemorrhage is certainly consistent with the nature of the disease and reflects the difficulty of establishing a well-documented diagnosis of intestinal bleeding when it is of very mild nature.

TABLE 8.—*Complications*

Complications	No.	Contributing to Fatality
Uremia	1	1
Cardiac failure	2	2
Jaundice	2	2
Ileus	2	0
Bronchopneumonia	4	2
Thrombophlebitis	2	0
Thrombophlebitis with pulmonary embolus	2	0
Wound disruption	1	0
Myocardial infarct	1	0
Malfunctioning stoma	1	0
Aspiration	2	2
Disruption of duodenal stump	2	2
Urinary retention	2	0
Postoperative hemorrhage	1	1
Pericarditis	1	1
Fibrinolysis	1	0
Pulmonary edema	2	2

TABLE 9.—*Analysis of Those Who Fainted*

	Fainted (34)		Did Not Faint (109)		Whole Group (143)	
	No.	%	No.	%	No.	%
Surgery 1st 48 hr.	9	26	5	5	14	10
Surgery 2–7 days	1	3	8	7	9	6
Surgery after 7 days	3	9	11	10	14	10
Total	13	38	24	22	37	26
Proved ulcer	22	65	60	55	82	57
Presumed ulcer	5	15	29	29	34	24
Suspected ulcer	7	20	20	19	27	19
Mortality	8	24	8	7	16	11
Hematemesis	25	74	44	40	69	48
Initial hemoglobin	9.3		9.8		9.7	
Pints of blood first 24 hr.	4.1		2.5		2.8	
Total blood	8.4		5.0		5.8	

Complications

The complications in our cases are listed in Table 8. We had 29 complications in 19 cases. The large number is, of course, quite consistent with the age group principally involved, and it is also obvious that many of these complications appeared together in one case, and in many instances contributed to our fatalities.

Mortality

Our mortality figures are presented and broken down into various categories in Table 6. The literature is replete with reports of mortality statistics in bleeding-ulcer cases, with a tremendous variation. Albright and Kerr[1] report such statistics from several series, with the surgical mortality ranging from 3.4% to 28.6%. Mathewson and Sugar[2] present an excellent discussion of surgical indications and a review from Stanford University Hospital of 215 patients with massive G. I. bleeding, with an over-all mortality of 33%. Many other examples can be cited but serve only to point up the obvious discrepancy in the figures from various reviews. Many sources of error immediately come to mind. Many of these series are limited to massive exsanguinating hemorrhages. Others include upper G. I. bleeding of all causes, such as bleeding varices, in which the mortality is understandably much higher. Other series include all operative cases, involving many cases in which operation was elective, thus markedly reducing the mortality figures. We feel that our surgical mortality of 26% represents a figure for those patients who would likely have died of their hemorrhage without surgery, and may be interpreted instead as a surgical salvage of 74%. Our over-all mortality of 11% would appear to be quite satisfactory in this group of very serious cases.

We subjected our 16 deaths to very close scrutiny, with some statistical conclusions that have several clinical implications. Hematemesis occurred slightly more frequently in the mortality group (56%) than in the survivors (47%). Fourteen of these patients had proved ulcers, a proportion which is much higher than that for the whole group. Syncope prior to admission would appear to be a poor prognostic sign, since one-half of our fatal cases gave such a history, whereas of the survivors only one in five had fainted prior to admission. The average age of our mortality cases (68 years) was about the same as that for the whole group. One-third of our patients who died had been subjected to emergency surgery during the first 48 hours of admission, and only one was operated upon late in his hospital stay as an elective procedure. Most of these patients gave a history of a relatively short duration of bleeding prior to admission, as might be anticipated. More than two-thirds of them had been bleeding for less than 24 hours, and all had been bleeding for less than 2

days. This is, of course, consistent with the clinical impression that the patient with sudden massive bleeding represents a much greater risk than one who is admitted after prolonged bleeding of less rapidity. In this same vein, it is interesting that the initial hemoglobin on admission averaged 9.6 gm. per 100 cc., as compared with 9.7 gm. for the whole group. Obviously, the initial hemoglobin is completely misleading, particularly in this group of patients with very severe rapid bleeding. This concept is further supported by following the subsequent hemoglobin determinations. In our mortality group, five patients (31%) had a subsequent hemoglobin determination at least 1 gm. below the initial determination, whereas only 23% of the survivors showed such a drop. This, of course, would imply either continued hemorrhage of considerable degree or inadequate blood replacement following admission. The mortality for patients showing such a hemoglobin drop was 15%, regardless of treatment. In patients without this finding the mortality was 10%. The blood replacement in our fatal cases was approximately the same as that for the survivors during the first 24 hours (1500 cc., as compared with 1400 cc.). However, the total blood replacement averaged 5000 cc. in the mortality group, as compared with 2900 cc. for the whole group. In only three of our fatal cases was survival more than 9 days following admission, and in one-half of them death occurred during the first 72 hours. In three of our six surgical fatalities death occurred within 24 hours of operation. The other patients, having survived the initial surgical trauma, died more than four days later. The distribution of the ulcers in our mortality group was very similar to the distribution in the whole group (Table 4). The causes contributing to death will be noted in Table 8. Obviously, these complications played a large part in our fatalities, as would be expected.

Significance of Syncope

Surely, all physicians who have any experience with upper G. I. bleeding have been impressed with the significance of fainting prior to admission. We thought it would be interesting to see whether we could demonstrate this prognostic significance statistically, and indeed we appear to have accomplished this. On examining Table 9, several things became apparent. Nearly twice as many of these fainting patients were subjected to surgery as were patients who had not fainted. This figure becomes even more interesting if we omit those cases in which operation was done late and limit our inspection to those in which operation was performed within the first 48 hours of the hospital stay. Here we find emergency surgery in 26% of the fainters and in only 5% of those who did not faint. The ability to demonstrate definitely an ulcer in these two groups of patients appears to vary very little. It may be significant that 65% of the fainters had a proved ulcer, as compared with 55% of those who did not faint.

The initial hemoglobin shows no significant variation in these two groups. When this information is added to the data on blood requirements of these two groups of patients, we have a graphic demonstration of an important basic concept of blood loss and blood replacement. During the first 24 hours of hospitalization patients who had fainted prior to admission required nearly twice the volume of blood needed by those who had not fainted. Again, we see that the initial hemoglobin reading is very unreliable as a measure of the amount of blood loss; rather, the clinical picture of shock or impending shock as manifested by syncope is our indication that blood loss is rapid and considerable and that we should anticipate greater requirements in blood replacement.

Approximately three-fourths of our patients who had fainted prior to admission gave a history of hematemesis, as compared with less than one-half of the patients who

did not faint. This, of course, is of no prognostic significance at the time of admission except that it again points up the fact that hematemesis in a bleeding ulcer generally signifies a greater amount of bleeding than in the patient who has not vomited blood.

The mortality figures dramatically demonstrate the prognostic significance of syncope. Of the patients who came to the hospital with a history of fainting, 24% died of this bleeding episode, as compared with only 7% of those patients who did not faint prior to admission.

Significance of Repeated Bleeding

In attempting to evaluate the surgical indications in a case of bleeding ulcer, a history of previous bleeding tends to influence us in the direction of surgery in a situation where the decision appears to be somewhat in doubt. Also, in determining the necessity for elective surgery in ulcer patients, repeated bleeding episodes are often weighed heavily in the direction of surgery. Among our 124 patients studied, 36 had experienced repeated bleeding. We should point out that the follow-up on our cases is of necessity very spotty, and that statements as to repeated bleeding in this survey must refer to the past rather than to future events. We found that 20 of these 36 patients with repeated bleeding (56%) were subjected to surgery at some time, either during a bleeding admission or between admissions. This compares with a surgical incidence of 36% in the entire group of 124 patients. These figures surely lose some of their significance in view of our inadequate follow-up studies, but undoubtedly with adequate follow-up the difference in surgical incidence between the two groups would increase rather than decrease. Thus, we see that the impression of the importance of repeated bleeding episodes in these patients appears to be justified.

The site of the ulcer in these 36 patients with repeated bleeding was very similar to that in the entire group; that is, it was duodenal in about 70% and divided between gastric and marginal in the remainder. There were a few more marginal ulcers in the patients with repeated bleeding than would be anticipated. This includes patients subjected to subtotal gastrectomy for bleeding who later developed ulcers with bleeding.

Blind Resection?

Once it has been decided that a patient must undergo surgery for control of ulcer hemorrhage, the most difficult decision has generally been made. However, occasionally one is faced at the operating table with a negative exploration in a case in which x-ray study either has been impossible, because of poor condition, or has been negative. What do we do when faced with this situation? For many years it has been the consensus that a blind two-thirds subtotal resection should be done under these circumstances. Recently interest has been developed in the idea that an ample longitudinal gastrotomy opening should be made and careful exploration of the mucosal lining of the stomach and duodenum carried out. We would like to lend our hearty support to this suggestion. We have a personal case included in this series which dramatically demonstrates the importance of this maneuver.

A 34-year-old woman was admitted to the hospital, having bled profusely from the upper G. I. tract for three days. On her second hospital day it became obvious that surgery was necessary to control the bleeding. A G. I. series had been done and was negative. At the time of exploration an entirely normal-appearing and normal-feeling stomach and duodenum were encountered. A conventional blind two-thirds subtotal gastrectomy was then performed according to the Billroth I technique. During her postoperative period, she soon began to bleed profusely again, with repeated hematemesis. Esophageal varices were again ruled out by a repeat G. I. series and

esophagoscopy. Finally, she was subjected to reexploration, and an open gastrotomy of the remaining gastric stump was done. At that time a very vigorous arterial bleeder was found in the gastric wall about 2 cm. above the gastroduodenostomy opening. The absence of any ulceration, or even induration about this area, was dramatic. Simple mattress sutures placed about this arterial bleeder stopped the hemorrhage, and recovery was uneventful, with no further bleeding.

Donaldson and Hamlin [4] report on massive hematemesis from rupture of gastric artery aneurysms. They describe three cases in which a small ruptured cirsoid aneurysm was demonstrated as the source of massive hemorrhage. The etiology rested with the arteriosclerotic changes in the vessels, rather than ulcerative changes in the mucosa.

Surely, the case we have described represents a similar situation, and this must explain many of the instances of massive upper G. I. bleeding where nothing can be demonstrated by palpation in surgery, and, indeed, nothing found by the pathologist on examining the surgical specimen or at autopsy. Obviously, a blind resection under these circumstances will be effective only if this bleeding point happens to fall within the distal two-thirds of the stomach. It is obvious that such a mutilating procedure as a partial gastrectomy is unnecessary under these circumstances, and simple ligation of the bleeding point or a small wedge resection is all that is required.

In our 143 cases there were 3 additional, somewhat similar cases in which no definite site of bleeding was found. Two of these patients were operated upon during the first 48 hours and were subjected to blind resection, with recovery. One of these had a negative preoperative x-ray; the other did not have a preoperative x-ray. Both had massive bleeding, requiring 13 pt. (6.5 liters) of blood in one instance and 8 pt. (4 liters) in the other. The third patient was not subjected to surgery but died after several days in the hospital, during which time 43 pt. (21.5 liters) of blood were given him. His x-ray was negative on two occasions, and careful exploration at autopsy failed to reveal any source of bleeding. It is our feeling that some or all of these cases may represent a gastric arterial rupture similar to that in the case described above. Certainly, this would be difficult to find except during the active bleeding at the time of gastrotomy exploration.

Summary

Over a seven-year period in a community hospital, 153 patients with upper gastrointestinal bleeding were hospitalized and treated. Of these cases, 143 were classified as bleeding ulcer. The latter group has been divided into 82 cases of proved ulcer, 34 of presumed ulcer, and 27 of suspected ulcer. These cases have been subjected to statistical analysis, and our preference as to the management of this type of case is presented.

We found the sex ratio of male to female patients to be 3.5:1, and 71% of all cases fell in the fifth, sixth, and seventh decades. The seasonal distribution did not appear to bear out the popular belief that these cases occur largely in the spring and fall. Of the 82 proved ulcers, 58 were duodenal, 17 gastric, 4 marginal, and 3 pyloric.

In our description of management, we stress the importance of an indwelling Levin tube with frequent aspirations in following the course of the bleeding, early x-ray study in locating the source of the bleeding, and medical-surgical team effort in following the patients.

We review briefly the indications for surgical intervention, dividing them into massive hemorrhage, repeated hemorrhage, and continuing hemorrhage. Of the cases studied, operation was performed in 26%. When the cases in which elective surgery was done late during the hospital stay were removed from this group, we found the need for emergency surgery in 13%.

The severity of hemorrhage was determined on the basis of the amount of blood replacement. On this basis the hemorrhage was considered severe in 60% of the cases.

We had 29 complications in 19 cases. Many of these complications contributed to the fatalities.

The over-all mortality was 11.2%. The mortality in patients subjected to emergency surgery was 26.3%. The mortality for those treated conservatively with or without later elective surgery was 8.9%. We analyzed the cases in which fainting occurred prior to admission and demonstrated the unreliability of the initial hemoglobin as a measure of blood loss and the relatively poor prognostic significance of syncope in those patients.

In the case of bleeding without an obvious source being found at the time of surgery, we recommend exploration of the stomach through an extensive anterior-wall gastrotomy, rather than a blind conventional two-thirds resection. Our reasons for this preference are described, together with an illustrative case.

121 Lincoln St. (8).

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A Surgical-Orthodontic Method of Correcting Mandibular Prognathism

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Introduction

The intent of this paper is to describe a procedure designed to correct mandibular prognathism by the combined efforts of oral surgery and orthodontics. This method is carried out completely within the oral cavity. It is the purpose of this procedure to improve the cosmetic appearance of the face and the function of the lower jaw.

Definition

A fullness or protrusion of the lower jaw, historically called the Hapsburg jaw, has been described in the literature by various references to cranial landmarks and facial planes[1-3] and is usually called mandibular prognathism (Fig. 5*A*).

Problem

Patients seek relief from mandibular prognathism for three primary reasons: (1) cosmetic improvement, (2) masticatory difficulties, and (3) pain and temporomandibular-joint difficulties.

Objectives

Solution of this problem is directed to produce (1) a more favorable facial appearance, (2) an occlusion more satisfactory for mastication, (3) relief from temporomandibular-joint difficulties if present (pain, clicking, etc.), and (4) a patient more favorably adjusted to his environment.

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Treatment Planning

If this facial and dental discrepancy can be corrected by conservative orthodontic means, it should be the treatment of choice. In certain instances the orthodontist recognizes the limitations of his technique, and in other instances his efforts have been unsuccessful. An orthodontically poor prognosis may be a combination of (1) marked family history of prognathism, (2) severe protrusion of the mandible accompanied by extensive protrusion of the mandibular incisor teeth, (3) marked obtuseness of the angle of the mandible, and (4) noticeable aberration of cranial landmarks as compared with cephalometric normals.

Where there is a poor orthodontic prognosis and the patient's motivation is of sufficient magnitude to lead him to seek treatment, the treatment of choice is surgery. This treatment should not be planned until the patient has attained full growth of the mandible. Early treatment may be partially undone by any latent growth tendencies in the condyle of the mandible. Full growth is usually reached between 17 and 21 years of age. Various surgical techniques are described for mandibular resections, ranging from osteotomy of the horizontal ramus to ostectomy of the body of the mandible.[4,5] In all of these procedures the approach to the mandible is extraoral, necessitating an incision on the skin. It is the purpose of the present paper to describe a method for correction of these anomalies which uses a completely intraoral approach, supported by an orthodontically designed splint.

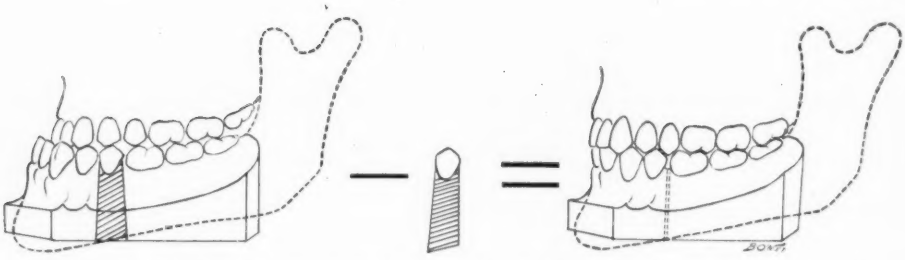


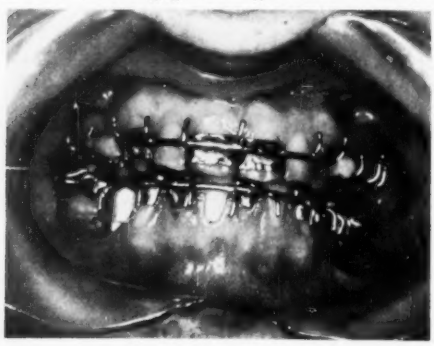
Fig. 1.—Schematic diagram to illustrate section of bone and tooth removed from dental casts and mandible.

Method

A. Orthodontic Means.—The amount of bone to be removed from the body of the mandible is accurately calculated prior to surgery. This is done from a set of the patient's dental casts, which are mounted on an articulator. Trial-and-error cuts are made on the plaster models until the desired occlusion is determined. The extent and direction of the resection necessary to produce this result may be ascertained from these models (Fig. 1).

The orthodontic splint is fabricated and cemented to place prior to surgery (Fig. 2). It is made from orthodontic bands to which are soldered heavy arch wires. The arch wires have multiple spurs to engage the elastics which will immobilize the jaws after surgery. The lower splint is in three sections (an anterior and a right and a left posterior), with provisions for rendering it rigid. After the segments have been excised, the anterior section is secured to the posterior segments by means of quick-setting plastic over loops of wire provided for this purpose. After cementation of the splint and allowing several days to test for any inadequacies, the patient is hospitalized.

Fig. 2.—Orthodontic splint cemented in position. This is fabricated from gold bands and arch wires soldered to the bands. Spurs are soldered to the arch wires to engage fixating elastics or wires.



B. Surgery.—Patients selected for treatment are carefully investigated for any contraindications to orthopedic surgery. An anesthesiologist is consulted for the evaluation of the patient's cardiac and respiratory systems and the selection of an appropriate anesthesia. Usually thiopental (Pentothal) induction and gas-oxygen-ether maintenance via nasoendotracheal tube constitute the most desirable form. This provides a well-controlled anesthesia with no obstruction to the oral cavity, where the operative procedure takes place.

After the patient is properly draped and prepared for surgery, a mouth prop is inserted to provide access to the field. A dampened gauze pack is placed about the tube in the pharynx, and at this time the tongue and buccal tissues are retracted to expose the dentition of one side of the mandible (Fig. 3). By sharp dissection, the gingival mucosal tissues are separated from the necks of the teeth, both lingually and buccally, the procedure extending from the most posterior molar forward to the canines at the corner of the mouth. A relaxing incision is made posteriorly into the buccal sulcus. A periosteal elevator is necessary to reflect and retract these tissues, the body of the mandible being exposed

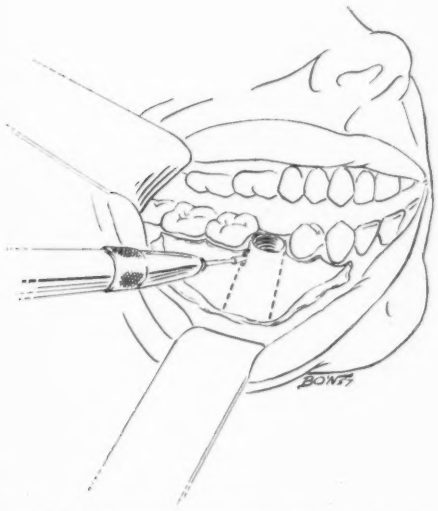


Fig. 3.—Drawing illustrating removal of section of bone from mandible with dental drill and burs.

circumferentially in the area where the resection is to be made. The sterilized metal template is placed on the position previously determined on study models and is scored with a high-speed rotary dental drill. The outlined block of bone is then removed by multiple drill perforations, which are subsequently connected. The cut surfaces of the mandible are now partially immobilized by crisscrossed stainless-steel wire (24-gauge) passed through two bur holes on either segment. This area is now covered with saline-soaked packing, and the opposite side of the mandible is exposed, resected, and wired in like fashion.

With the mandible now in three separate segments, the orthodontist and surgeon can freely manipulate the anterior segment. Minor surgical adjustments on the cut surfaces by means of burs and bone files allow the orthodontist to adjust the occlusion as he desires. When the teeth are appropriately meshed, the transosseous wires are tightened on the inferior border as one point of fixation. The mucosal tissue is sutured back about the necks of the teeth and over the wound. The pharyngeal packing is removed. A minimum number of elastics are applied to the orthodontic appliance in order to approximate the maxillary and mandibular teeth. The endotracheal tube is left in place until the patient is fully conscious. The patient's face and neck are kept covered with crushed ice packs, renewed every 20 minutes for the first 24 hours. Precautions are taken to prevent respiratory difficulties. A vacuum-suction catheter is constantly present, as well as scissors for cutting the intermaxillary elastics in the event of vomiting. Intravenous fluids and nourishment are started at the end of the operative procedure and are usually the only fluids necessary.

A summary of the advantages and disadvantages of this technique may be listed as follows:

Disadvantages

1. Anesthesia or paresthesia of the lower lip and teeth for six or more months.
2. Prolonged fixation (six to eight weeks).
   (*a*) Fluid and semifluid nutrition.
   (*b*) Muffled speech.
   (*c*) Poor oral hygiene.
3. Possibility of wound infection.

Advantages

1. No facial scarring is left.
2. Occlusion is established by the operating team and is not dependent on muscle pull, as in osteotomy. A faulty muscle pull may cause relapse of the occlusion and an opening of the bite.
3. Orthodontic fixation provides for fine adjustment of the occlusion during the healing period.

Report of a Case

Examination.—A 24-year-old white, unmarried woman student was referred by her local dentist for evaluation of her severe malocclusion and temporomandibular pain. The patient had very early recollections of a prominent lower jaw (Fig. 5*A*). During the past five years, there had been pain of increasing magnitude in the preauricular regions. The patient had undergone many E. N. T. and oral examinations and had received no relief. Concurrently, she had noted decreasing hearing ability—more pronounced on the left side.

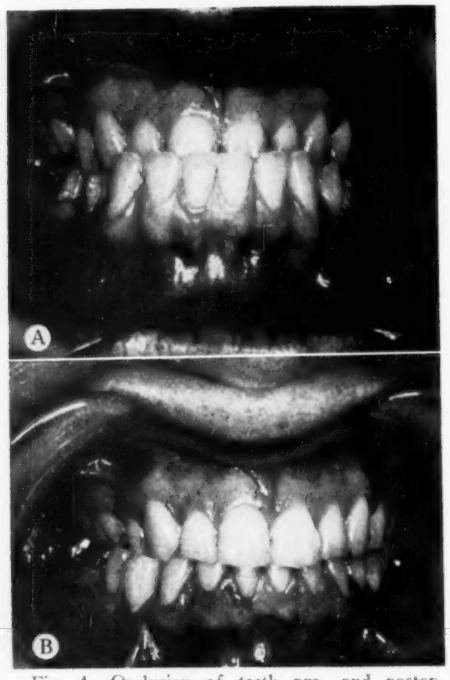


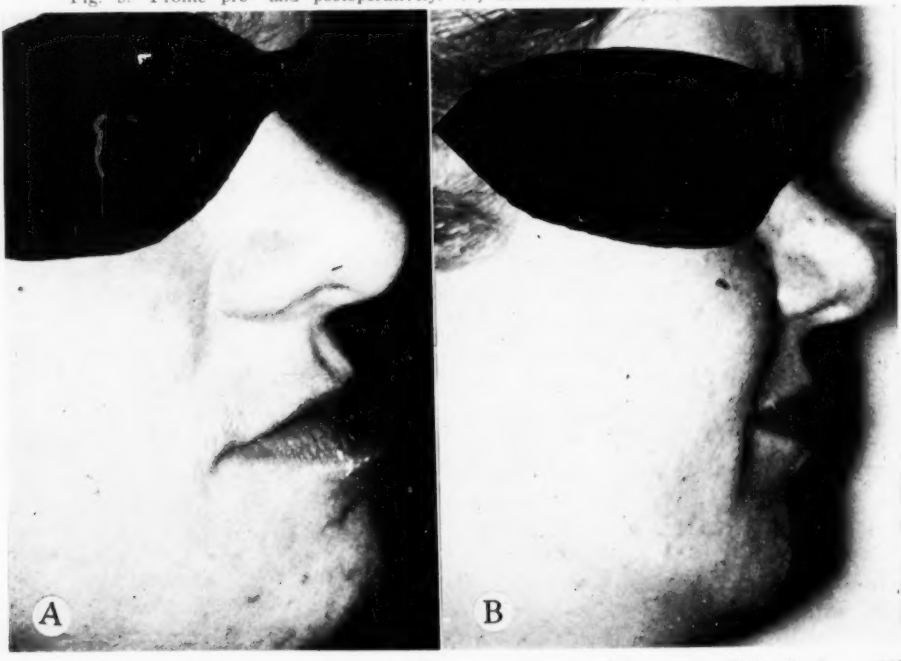
Fig. 4.—Occlusion of teeth pre- and postoperatively. *A*, before resection; *B*, after resection.

The patient stated she had excellent health. She had had the usual childhood diseases and an uneventful tonsillectomy and adenoidectomy. Until recently, she had been undergoing a series of desensitizing injections for allergies to pollen, fur, feathers, and common foodstuffs. The patient denied having had scarlet fever, rheumatic fever, or renal, hepatic, or cardiac disease. There had been no evidence of diabetes, hyperpituitary dysfunction, or bleeding tendencies. There was normal onset and regularity of menstrual function.

After an oral, facial, and cephalometric examination, a diagnosis of familial prognathism was made. The mother and one sister are both prognathic but have had no associated temporomandibular-joint pain. A study of the opening and closing positions of the mandible revealed an exaggerated protrusive position for functional relations in occlusion. A temporary plastic appliance was made which discouraged this protrusive position. The patient wore this for six months, and marked relief and decrease of frequency of temporomandibular pain were noted.

At the end of six months the patient was reevaluated and informed that there was a choice of two procedures. A permanent prosthetic appliance could be made to maintain the improved occlusion, or a surgical repair could be performed both to maintain the correction in the occlusion

Fig. 5.—Profile pre- and postoperatively. *A*, before resection; *B*, after resection.



and to produce cosmetic improvement. The patient insisted that she desired the surgical correction.

The operative procedure was planned on study models by the orthodontist and the surgeon, after which templates were designed to indicate the amount of bone to be removed. Intraoral appliances were designed and placed in position by the orthodontist (Fig. 2). These were tested for a period of five days for stability, after which the patient was admitted to the hospital.

Admission Studies.—Urine: Normal; specific gravity 1.012; no sugar. WBC, 13,100 per 100 cc.; Hgb, 11.8 gm. %; smear, normal. Blood type, O Rh+. Bleeding and clotting times, normal.

The patient was started on Crysticillin (procaine penicillin G in aqueous suspension), 300,000 units, and taken to the operating room 12 hours later. The surgical procedure was carried out under intravenous thiopental (Pentothal) anesthesia, and the patient received 500 cc. of whole blood and 800 cc. of dextrose in water during the procedure.

Antibiotic therapy (penicillin, 300,000 units, and streptomycin, 0.5 gm. every six hours) was initiated. Ice packs were applied to the face. Twenty-four hours postoperatively there was marked edema of the inferior lip and submandibular areas. Thirty-six hours postoperatively edema had markedly diminished. There was no bleeding, and the temperature was normal (99.2 F per rectum).

The intermaxillary fixation was adjusted daily, and postoperative x-rays were taken on the second day. The patient did not require intravenous fluids postoperatively, since oral intake was adequate. On the third postoperative day, when the swelling had diminished, streptomycin was discontinued. The temperature remained normal, and x-ray examination revealed good alignment.

The patient was discharged, on oral penicillin therapy, 1,000,000 units per day, on the fourth postoperative day. She resumed her studies on the sixth postoperative day.

Photographs of the occlusion before and after operation may be seen in Figure 4. The profile of the patient as it appeared preoperatively and then six months following surgery may be seen in Figure 5.

Summary

A modified surgical-orthodontic method for correcting mandibular prognathism is described. This procedure is carried out completely within the oral cavity. A case illustrating this technique is summarized.

Children's Hospital, 300 Longwood Ave. (15).

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Cosmetic Correction of Severe Mandibular Retrusion

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Retrusion of the mandible is characterized by posterior displacement of the entire lower jaw. It may be a unilateral or a bilateral deformity but is more frequently the latter. In all such defects of the lower jaw there is some degree of bony hypoplasia; often there is an actual loss of bone with much distortion of the anatomic structures of the mandible. Malocclusion is invariably present, and underdevelopment and recession of the symphysis may accentuate the deformity. The most conspicuous feature in all cases of mandibular retrusion is retraction of the chin; this may or may not be associated with shortening of the upper lip (Figs. 1 and 2).

Retrusion of the mandible may be due to (1) malocclusion alone or (2) arrested growth of the lower jaw complicated by malocclusion.

In all patients having mandibular retrusions resulting from malocclusion and characterized by a distal relationship of the lower to the upper dental arches, the etiologic aspects of the condition and the treatment of the patients are entirely orthodontic problems.

In patients in whom the retruded mandible is not caused by malocclusion alone, there are two sets of etiologic factors: primary and secondary. The primary factors arrest the growth of the mandible or disturb its continuity or its confirmation. Such factors are osteomyelitis, temporomandibular ankylosis, unreduced fractures of the lower jaw, particularly bilateral subcondylar fractures, and birth injuries. When these factors occur in childhood, the deformity of the mandible becomes accentuated with the growth of the mandible. The secondary etiologic factors relate to malocclusion, which is a complication of the original deformity.

It is this second group of patients in whom the plastic surgeon is particularly interested. If the retrusion does not amount to more than 1 cm. of posterior displacement of the lower jaw, treatment may involve osteotomy of each ramus, followed by sliding of the body of the mandible forward, or bilateral step osteotomy of the body and sliding of the anterior fragment forward. However, such surgical procedures do not provide more than 1 cm. advancement for the lower jaw. Consequently, in cases of severe retrusion, such as this paper concerns, these types of osteotomy are useless. Furthermore, in my experience at the Mayo Clinic, most patients with retrusion severe enough to warrant surgical intervention have more than 1 cm. of posterior displacement.

If retrusion is greater than 1 cm., treatment can be carried out in one of two ways: (1) by means of cartilage or bone grafts inserted over the symphysis mandibulae to build out the chin and use of an intraoral prosthetic appliance to hold the lower lip forward, or (2) by means of an intraoral prosthetic appliance alone (Figs. 1 and 2). In either case, when a prosthetic appliance is employed, a pocket must be prepared surgically behind the lower lip and lined with a free split-thickness skin graft.

I have practically discontinued the first method, that is, the use of cartilage and bone grafts over the chin and an intraoral appliance. My reason for not using cartilage or bone to build out the chin involves

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Section of Plastic Surgery, Mayo Clinic and Mayo Foundation. The Mayo Foundation, Rochester, Minn., is a part of the Graduate School of the University of Minnesota.

Fig. 1.—(*a*) Severe retrusion of the mandible due to bony ankylosis of the left temporomandibular joint secondary to an infection following measles. (*b*) After arthroplasty, the deformity of the chin was corrected by preparing a skin-grafted pocket back of the lower lip and chin and inserting an intraoral prosthesis.

the fact that a retruded jaw has considerable posterior displacement of the lower anterior teeth in relation to the upper dental arch. Accordingly, when cartilage or bone is used to build out the chin, an acceptable cosmetic result is not effected. On the contrary, the deformity is accentuated by the insertion of the graft, because the lower lip is still drawn back by its mucosal attachment to the gum tissue about the lower anterior teeth (Fig. 3*b*). This retraction of the lower lip must be corrected by incising the mucosal attachment and inserting a prosthetic appliance between the lip and the alveolar process in a skin-lined pocket (Fig. 3*c*). My contention is that if an intraoral appliance is necessary in addition to bone or cartilage in order to build up the chin, the contour of the chin might just as well be reconstructed with an intraoral appliance

Fig. 2.—(*a*) Severe retrusion of the mandible secondary to bony ankylosis of the temporomandibular joints. (*b*) After arthroplasty, the deformity of the chin was corrected by preparing a skin-grafted pocket back of the lower lip and chin and inserting an intraoral prosthesis.

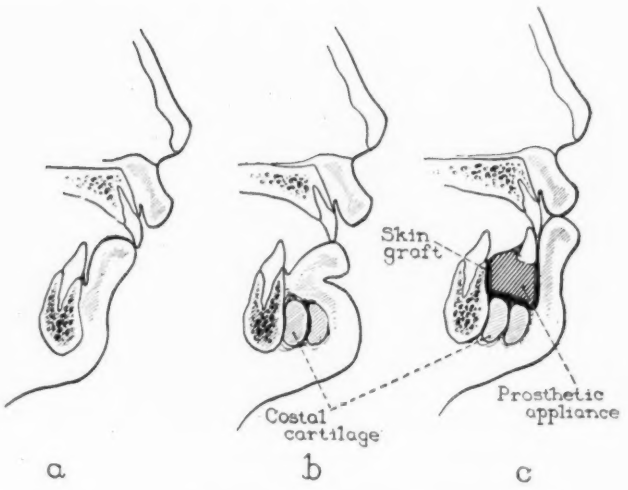

Fig. 3.—Median-line section of face of patient with mandibular retrusion. (*a*) Preoperative appearance of retruded chin. (*b*) Two pieces of costal cartilage build out the chin, but the lower lip is still retracted by its mucosal attachment to the lower jaw. (*c*) Normal contour of lower lip produced by a prosthetic appliance.

alone. Moreover, in many patients the mandible is greatly underdeveloped or is displaced so far posteriorly that a cartilage or bone graft would not even begin to build up the chin to normal contour; in such cases the deformity must be corrected entirely by an intraoral appliance. Consequently, I believe that the average patient who has retrusion of the mandible with more than 1 cm. of posterior displacement should be treated by the preparation of a skin-lined pocket and use of a prosthetic appliance. This is the quickest and simplest form of treatment and will produce the most satisfactory cosmetic effect.

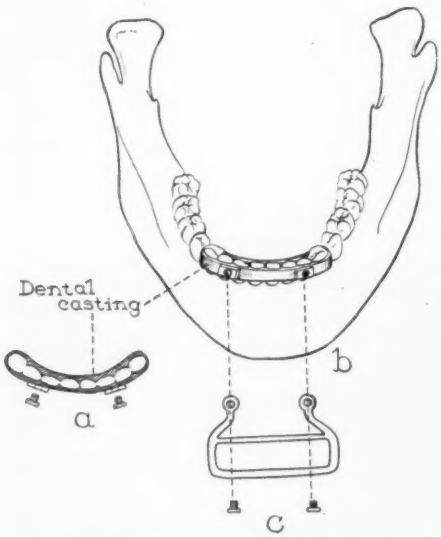

Fig. 4.—Appliance for fixation of a skin graft used in lining a pocket between the lower lip and the alveolar process for reception of a prosthetic appliance. (*a*) Silver dental casting as seen from above. (*b*) Casting cemented to lower anterior teeth. (*c*) Wire frame for holding dental modeling compound, around which the skin graft is wrapped. Two small screws anchor the wire frame to the casting.

To free the lower lip and chin from their attachment to the lower jaw, sharp dissection is employed, and an incision is made through the mucous membrane of the labioalveolar sulcus from one bicuspid region to the other. This incision is carried down between the alveolar process and the lower lip to and around the lower border of the anterior part of the mandible, care being taken not to injure the mental nerves. The result of this procedure is the creation of a pocket, which must be lined with skin for the reception of an artificial appliance.

The problem in skin grafting such a cavity is to obtain absolute fixation of the part during the healing period. Needless to say, immobilization is an important factor in successful skin grafting. I have developed the following technique for maintaining fixation, and, without exception, it has given excellent results. As a preliminary

measure, a silver dental casting or splint, which is cemented to the lower teeth, is prepared by the dentist (Fig. 4). On the anterior aspect of this casting are two threaded holes into which steel screws may be turned. A wire frame also is constructed which can be fastened securely by the screws to the casting. If screws and taps for threading holes in the casting are not available, the silver splint can be prepared with little hooks, under which the frame is seated. The subsequent upward force of the soft tissues on the frame prevents it from being dislodged from the hooks.

After the preparation of the pocket between the lower lip and the alveolar process, the wire frame is fixed to the casting and adjusted so that it lies in the center of the wound. It is then removed and coated with a thin layer of dental modeling compound which has been melted in a flame. The compound, softened in this manner, will adhere perfectly to the frame, whereas compound softened in hot water will not. After reattachment of the compound-covered frame to the casting, a cake of modeling compound is softened in hot water and packed down around the frame into the pocket. When hard, the water-softened compound and the compound-coated frame adhere together and form a stent that is perfectly adapted to all irregularities of the pocket. On removal from the mouth, the stent is coated with rubber cement or a solution of mastic in benzene (Mastisol). A thin split-thickness skin graft, which is cut from the abdomen preliminary to the intraoral operation, is wrapped about the stent and sutured along its upper surface. The stent, covered with the skin graft, is then inserted into the pocket and screwed to the dental casting. Adhesive plaster applied externally firmly fixes the lower lip to the stent, which is immovable.

After 7 to 10 days, the stent and silver splint may be removed, and the pocket will be found to be lined perfectly with skin. Inserted into this cavity is the prosthetic appliance, which, like any partial denture, is attached by clasps to the lower teeth. Such a prosthesis is prepared with artificial lower anterior teeth, making it mandatory that the patient's own lower incisor and cuspid teeth be removed. In effect, then, the prosthesis not only restores the lower lip and chin to natural contour but also establishes an external semblance of normal dental occlusion.

For a few days after the prosthetic appliance is inserted, the lower lip, which is stretched and tense, has a tendency to contract downward; to counteract this reaction, adhesive tape must be used to hold the lower lip in the desired position. As a matter of fact, in some cases the lower lip is so short and tense that it will not meet the upper lip; under such circumstances, rubber-band traction from adhesive tape on the lower lip and chin to a head bandage above is required to stretch the lower lip upward to a desirable position, a matter which requires five or six days. Two or three months is required for the muscles of the lower lip to develop sufficiently so that the lower lip loses its tense appearance and assumes a natural contour.

In conclusion, I wish to emphasize that the deformity of severe mandibular retrusion can be cosmetically corrected as well, if not better, by means of an intraoral prosthesis inserted into a surgically prepared and skin-grafted pocket behind the lower lip and chin as by means of such a pocket and appliance used in conjunction with cartilage or bone grafts to build out the contour of the chin.

Section of Plastic Surgery.

Ristocetin and Ristocetin-Neomycin for Preoperative Preparation of the Colon

ISIDORE COHN Jr., M.D., D.Sc. (Med.), and ALFRED B. LONGACRE, M.D., New Orleans

Interest in antibacterial agents for preoperative preparation of the bowel has stimulated us to evaluate new agents by standardized techniques which permit comparisons of different agents.[1,2,7] Ristocetin, isolated from the actinomycete Nocardia lurida recovered from a Colorado soil sample, has been reported to be particularly effective against staphylococcal infections and not to induce bacterial resistance as easily as some other antibiotics.[9-12] The rising incidence of staphylococcal problems made this substance an interesting drug to evaluate for preoperative intestinal antisepsis.

Methods

Patients in good general condition were chosen at random from the surgical service,* provided they had no known colonic lesions. During the period of study they received only those antibacterial agents administered for intestinal antisepsis. The patients were not subjected to surgery during the period of investigation.

After a control stool was obtained, the patients were placed on a program similar to that for patients being prepared for large-bowel surgery. A low-residue diet, a laxative the first day of therapy, and daily enemas thereafter added mechanical cleansing to the program for reduction of the bacterial flora of the colon.

Bacteriologic analyses were conducted on stools collected before therapy, each day during therapy, and for one to two days after therapy. Drug sensitivity of the organisms recovered in the stool each day was evaluated.

Bacteriologic techniques were identical with those used in previous studies.[1,2,7] Briefly, these consisted of serial dilutions of a weighed quantity of stool and aerobic and anaerobic plating of each dilution so as to obtain 15 initial plates from each stool specimen. Colony counts were made at appropriate intervals and organisms identified through Gram-stain smears and subcultures as necessary. Additional subcultures or additional tests were performed when necessary. Identification of the various organisms followed the same techniques reported in previous studies.

Disks containing various concentrations of the drug were used for sensitivity studies.

Ristocetin

Ristocetin was administered orally † to five patients, 250 mg. every hour for 4

† Oral therapy was obtained by placing the intravenous powder in capsules.

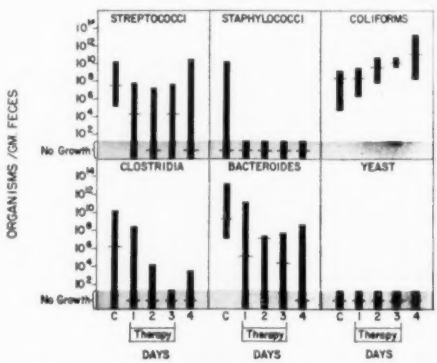

Fig. 1.—Effect of three days of therapy with oral ristocetin on bacteria in feces. Bars indicate maximum and minimum values for each day. Cross marks indicate median value.

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Department of Surgery, Louisiana State University School of Medicine.

Bacteriologic determinations were conducted by Bette M. Beauclair, B.S., and Esther C. Alexander, B.S.

Ristocetin was supplied by Abbott Laboratories as Spontin. Ristocetin-neomycin was supplied by Abbott Laboratories as Spontin-Neomycin.

Aided in part by Research Grants No. E-1600 and E-524-(C4) from the National Institute of Allergy and Infectious Diseases of the National Institutes of Health, U. S. Public Health Service.

* Louisiana State University Surgical Service of the Charity Hospital of Louisiana at New Orleans.

hours, then 250 mg. every 6 hours for a total of 72 hours (Fig. 1).

Streptococci, present in all control specimens, were removed from all but one patient by the second day of therapy. They were removed from this patient on the last day of therapy but reappeared in another patient. Streptococci were recovered from only one patient on the day after therapy.

Staphylococci were present in two control specimens but were not recovered from either of these by the first day of therapy. Staphylococci were not recovered again.

Coliform organisms were present in all patients and were not significantly affected during the study.

Clostridia were present in the control specimens of three patients but were not present at the end of therapy in any of these patients. They appeared for the first time on the day after therapy in one patient.

Bacteroides were present in all control specimens and were still present in three at the end of the second day of therapy. One patient continued to have bacteroides at the end of therapy, and two others had bacteroides in the specimens obtained after therapy.

Yeasts were not recovered at any time.

In addition to the organisms specifically listed, Proteus was found in all five patients, Pseudomonas in three, and aerobic Gram-positive rods in two. Sensitivity studies showed all the Proteus and Pseudomonas strains to be resistant to ristocetin.

Sensitivity studies were conducted using disks containing 5μg. and 50μg. of ristocetin. Daily sensitivity studies were conducted, but only results before and after therapy are charted to simplify the reporting (Table 1).

All streptococci in the control specimens were sensitive at the 5μg. level. Only two patients developed resistant strains, one on the first day of therapy and one at the end of therapy.

The staphylococci which were recovered from two patients were sensitive to the drug—one at the 5μg. level and the other at the 50μg. level.

All coliform organisms were resistant.

Clostridia in one patient were resistant to the drug, but in all others were sensitive.

Bacteroides were sensitive in four patients, half at the 5μg. level and half at the 50μg. level, but resistant in the fifth patient. By the end of therapy resistant forms had been found in all five patients.

Ristocetin and Neomycin

Ristocetin and neomycin were originally administered orally in the following dosage: ristocetin, 400 mg., combined with 1.0 gm. of neomycin sulfate every hour for 4 hours, then every 6 hours for a total of 72 hours. In five patients so treated there was disappearance of streptococci, staphylococci, coliform bacteria, and bacteroides by the end of the first day of therapy, control of clostridia by the end of therapy, and an upsurge in the yeast count beginning on the first day of therapy. However, one patient had nausea after 24 hours of therapy; one had intense abdominal pain after 48 hours of therapy, and one had to discontinue therapy because of nausea and vomiting. The high proportion of undesirable side-reactions made this dosage unsatisfactory.

Experience with other drugs in combination with neomycin had shown that dividing the usual dose in half provided as

TABLE 1.—*Sensitivity Studies Before and After Ristocetin Therapy*

	Streptococci		Staphylococci		Coliforms		Clostridia		Bacteroides	
Patient	Before	After	Before	After	Before	After	Before	After	Before	After
1	S[5]	NG	NG	NG	R	R	R	NG	S[5]	NG
2	S[5]	NG	S[5]	NG	R	R	S[5]	NG	S[5,50]	NG
3	S[5]	NG	NG	NG	R	R	NG	S[5]	S[5]	R
4	S[5]	NG	S[5,50]	NG	R	R	S[5]	NG	S[5,50]	R
5	S[5]	R	NG	NG	R	R	NG	NG	R	R

satisfactory bacterial control and a decreased incidence of undesirable gastrointestinal side-effects.[3,8] It was therefore decided to try this combination in a decreased dose.

Five patients were studied with the following drug schedule: ristocetin 200 mg. combined with neomycin sulfate 500 mg. every hour for 4 hours, then every 6 hours for a total of 72 hours.

Streptococci (Fig. 2) were present in all control specimens but were not subsequently recovered during therapy. They returned in two patients two days after therapy was discontinued.

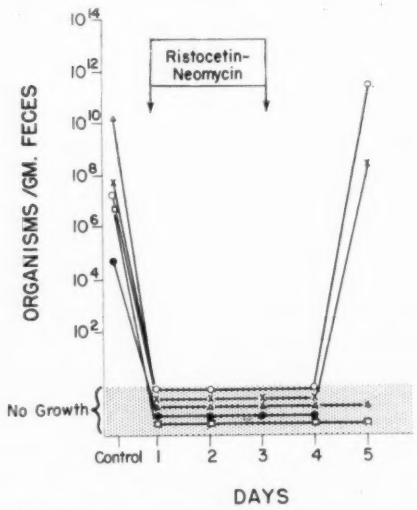

Fig. 2.—Streptococci per gram of stool in patients on ristocetin-neomycin for three days. Each symbol represents one patient. In this Figure, and in the subsequent Figures, the clear circle indicates Patient 1a; the cross, Patient 2a; the triangle, Patient 3a; the solid circle, Patient 4a, and the square, Patient 5a. Symbols are plotted only for days when specimens were obtained and studied. Symbols in area of "*No Growth*" indicate specimens analyzed and found free of these organisms.

Staphylococci (Fig. 3) were recovered in only one control specimen and were not otherwise found during the study.

Coliform organisms (Fig. 4) were found in all control specimens but were found in only one patient by the second day of therapy. The one patient who continuously had coliform organisms had an Aerobacter,

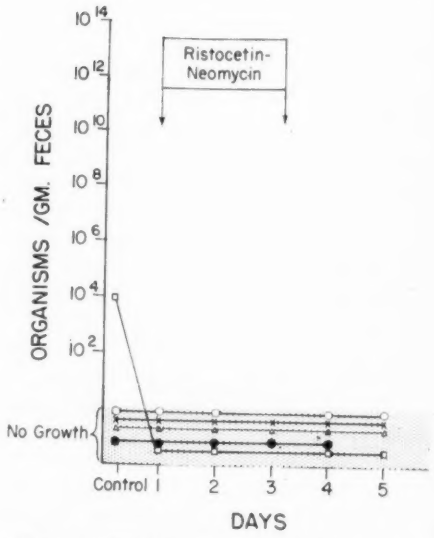

Fig. 3.—Staphylococci in stool during and after ristocetin-neomycin therapy.

which was sensitive in vitro to 5μg. of neomycin sulfate but was not controlled by the two drugs.

Clostridia (Fig. 5) were present in all control specimens but were recovered from only one patient on the second day of ther-

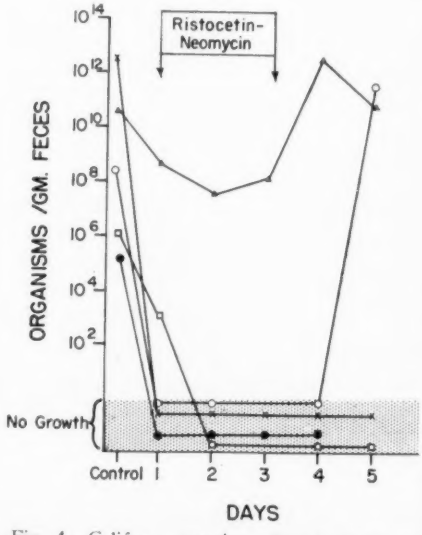

Fig. 4.—Coliform organisms found during and after ristocetin-neomycin therapy.

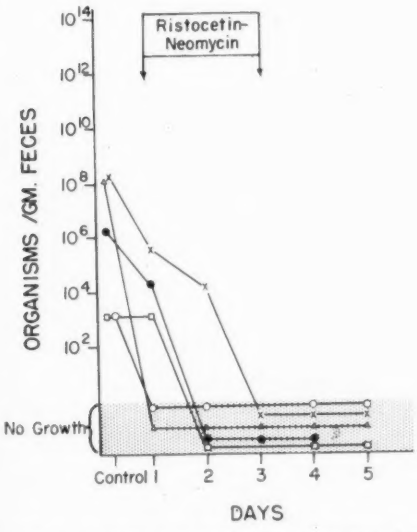

Fig. 5.—Clostridia in stool of same patients during and after ristocetin-neomycin therapy.

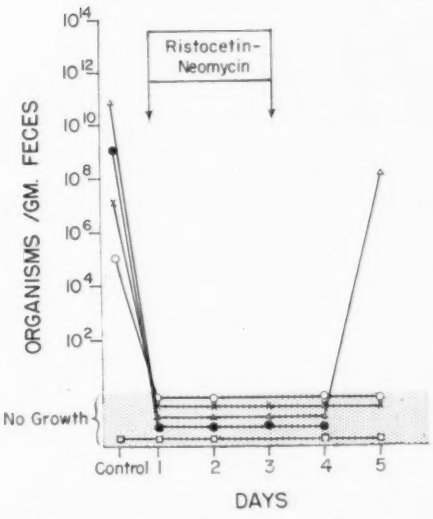

Fig. 6.—Changes in bacteroides in stool of patients on ristocetin-neomycin therapy.

apy and were not recovered from any patients by the end of therapy.

Bacteroides (Fig. 6) were present in four control specimens, but were not again recovered during therapy. They were found in one patient on the second day after therapy.

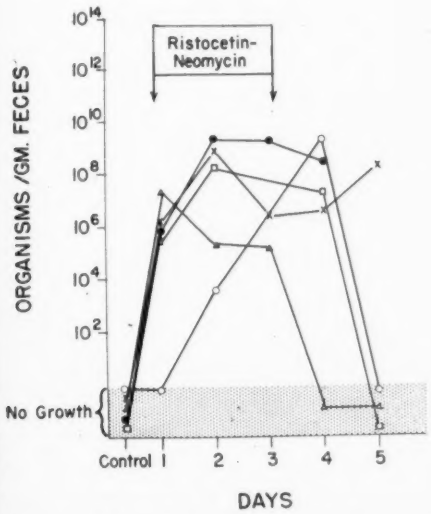

Fig. 7.—Effect of ristocetin-neomycin therapy on yeasts in same series of patients.

Yeasts (Fig. 7) were not recovered from any control specimens, but were recovered from all patients by the second day of therapy and continued to be present until one or two days after therapy, when they began to disappear again.

In addition to the above organisms, Proteus species were found in two patients and Gram-positive rods in one.

Sensitivity studies were conducted using disks containing 5μg. and 50μg. of each of the drugs alone and in combination in both concentrations on a single disk. The results are reported only for the drugs separately, since these and previous studies have indicated that the results obtained using the two agents separately were identical with those using the two agents together (Table 2).[4-6]

All streptococci in the control specimens were sensitive to ristocetin at the 5μg. level. Three were sensitive to neomycin sulfate at the 5μg. level, while the other two were sensitive to neomycin at the 50μg. level. There was no change in sensitivity to ristocetin after therapy. Sensitivity to 50μg. of neomycin sulfate remained unchanged in

TABLE 2.—*Sensitivity Studies Before and After Ristocetin-Neomycin Therapy*

Patient	Streptococci				Staphylococci				Coliforms				Clostridia				Bacteroides			
	Before		After		Before		After		Before		After		Before		After		Before		After	
	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin	Ristocetin	Neomycin
1a	S*	S*†	S*	S*†	NG	NG	NG	NG	R	S*	R	S*	S*	R	NG	NG	S*	R	NG	NG
2a	S*	S*†	S*	R	NG	NG	NG	NG	R	S*	NG	NG	S*	R	NG	NG	S*	S*	S*	NG
3a	S*	S*	NG	NG	NG	NG	NG	NG	R	S*	R*	S*	S*	R	NG	NG	S*	R	NG	NG
4a	S*	S*†	NG	NG	NG	S*	NG	NG	R	S*	NG	NG	S*	R	NG	NG	S*	NG	NG	NG
5a	S*	S*	NG	NG	S*		NG	NG	R	S*	NG	NG	S*	R	NG	NG	S*	NG	NG	NG

one patient, but streptococci which had been sensitive to 5μg. of neomycin sulfate became resistant in another patient.

Staphylococci, found in only one control specimen, were sensitive to 5μg. of either ristocetin or neomycin.

All coliform organisms were sensitive to 5μg. of neomycin sulfate, and all were resistant to ristocetin. There was no change in this response throughout therapy.

All clostridia were sensitive to 5μg. of ristocetin, and all were resistant to neomycin. This response was unchanged during therapy.

Bacteroides present in the four control specimens were all sensitive to 5μg. of ristocetin and resistant to neomycin in three patients. The fourth patient had bacteroides sensitive to 5μg. of neomycin. The bacteroides recovered after therapy showed an unchanged sensitivity to ristocetin, but the resistance to neomycin had changed to a sensitivity at the 5μg. level.

Comment

Quantitative bacteriologic evaluation of the changes in the fecal flora in patients receiving ristocetin alone and in combination with neomycin shows that the combination of these two drugs provides satisfactory control of the fecal flora and that most organisms found in the stool are likely to be sensitive to one or the other of the drugs. Resistance has not been shown to develop to a significant degree during the short period of therapy that provides satisfactory control of the fecal flora.

A low incidence of gastrointestinal side-reactions in patients receiving the drug combination provides a satisfactory margin of patient acceptability.

The poor absorption of this drug combination from the gastrointestinal tract [12] is a desirable feature, since this would tend to prevent widespread use of such a drug combination in routine hospital practice. The effectiveness of ristocetin against staphylococci and its minimal absorption from the gastrointestinal tract are addi-

tional arguments for such an agent for preoperative preparation of the colon.

On the other hand, since ristocetin is particularly effective against resistant staphylococci, it should not be used indiscriminately for fear that this very property will be lost. While this feature makes it useful, it also makes it desirable to restrict the use of ristocetin-neomycin combination either to those cases in which staphylococcal troubles already have developed, or to those where previous therapy for other conditions has increased the possibility of developing such a complication. While the combination can be highly recommended as a satisfactory agent for control of the fecal flora, it cannot be recommended for routine use for fear that the drug might thereby render itself less effective.

Summary

Ristocetin alone is not a good agent for intestinal antisepsis.

Ristocetin in combination with neomycin provides one of the most effective means of controlling the fecal flora.

To prevent the loss of the antistaphylococcal activity of ristocetin, its use in combination with neomycin should be reserved for those specific indications in which it is urgently needed.

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Perianal Rhabdomyosarcoma

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Rhabdomyosarcoma is a well-recognized malignant mesenchymal neoplasm most frequently arising in the skeletal muscles of the extremities.[1-9] In addition, it may represent a component of a neoplasm in which other mesenchymal or mesodermal elements may be identified: the so-called malignant mesenchymoma, or mixed mesodermal tumor, which is most frequently observed in the genitourinary tract.[10] Documented examples of rhabdomyosarcoma have also been noted in such unusual sites as the parotid gland, thyroid, adrenal, bronchus, lung, ovary, and cerebellum.[10-12] In some of the neoplasms in these latter structures other tissues have not been identified, and it has been suggested that they are derived from undifferentiated mesenchyme in such structures.[10]

Only a few examples of rhabdomyosarcoma arising in the gastrointestinal tract have been recorded. These have occurred in the tongue, oropharynx, esophagus, sites which normally possess skeletal muscle,[10] and in bile ducts.[3] Benenati[13] referred to a rhabdomyosarcoma of the anus in his review of malignant tumors of skeletal muscle; however, clinical and pathological details were not presented. We have been unable to find another reference to rhabdomyosarcoma at this site.

The purpose of the present report is to call attention to this rare type of perianal tumor, as well as to relate some of its pathological features which appear worthy of note.

Report of a Case

A 25-year-old white man first noticed a painful perineal mass accompanied by pain on defecation three years prior to death. There were no other gastrointestinal complaints. Examination at this time was negative except for a small, tender mass in the right posterolateral aspect of the anal wall. The overlying anorectal mucosa was intact. An excisional biopsy was performed.

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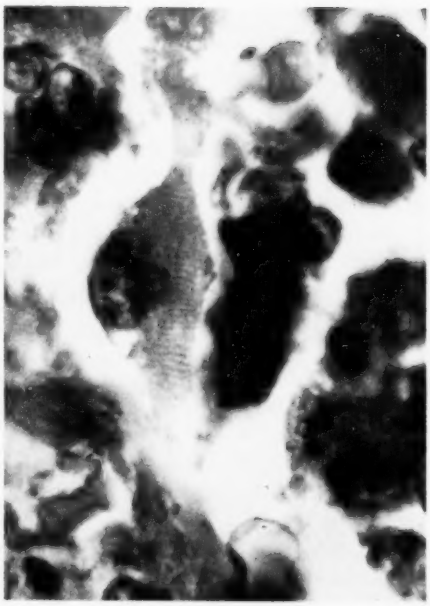


Fig. 1.—Cross striations apparent in fusiform tumor cell. Pleomorphism of other cellular elements is evident. Hematoxylin-eosin; × 1250.

First Biopsy.—The specimen consisted of a lobulated, soft, tan mass, measuring 3.4×2.5×2 cm., with a small segment of intact anal mucosa apparent on one surface.

Microscopic examination revealed a malignant mesenchymal neoplasm formed by large spindle and tadpole- or racquet-shaped cells with abundant eosinophilic cytoplasm, in which cross and longitudinal striations and occasional vacuoles could be readily identified (Fig. 1). Cell nuclei were round, oval, and pleomorphic, with prominent nucleoli. Mitoses and bizarre nuclear forms were not infrequent. Fibrous septa of varying thickness

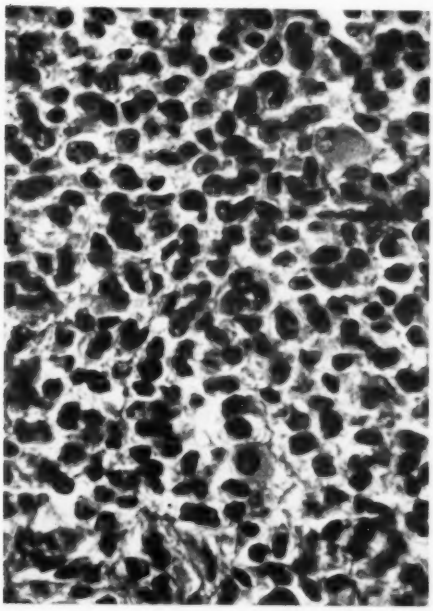


Fig. 2.—Indistinct round cells of rhabdomyosarcoma which were present in many areas. × 400.

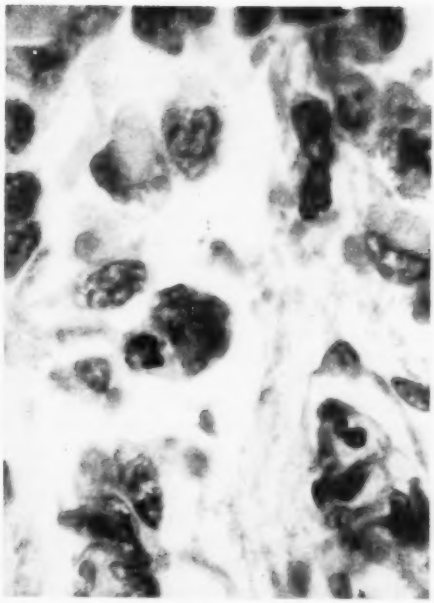


Fig. 3.—Centriole cluster in cytoplasm of tumor cell in center of field. × 850.

Fig. 4.—Alveolated pattern in rhabdomyosarcoma. × 125.

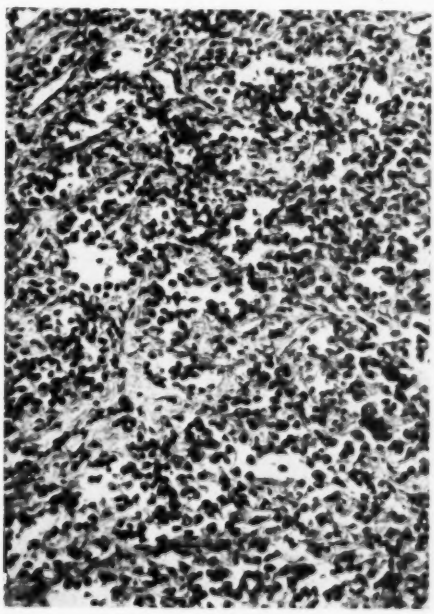
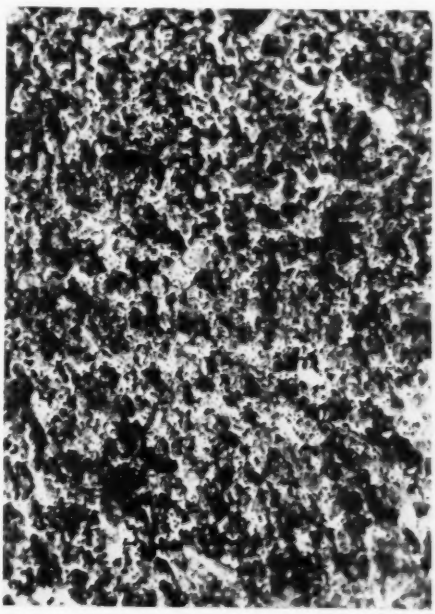


Fig. 5.—Abundant glycogen in tumor cells of rhabdomyosarcoma. Periodic acid-Schiff technique; × 260.



coursed throughout the neoplasm. Normal-appearing skeletal muscle at one edge appeared contiguous with the neoplasm.

Diagnosis: Rhabdomyosarcoma.

Course.—The perineal mass recurred within two months following this procedure, and the patient was transferred to the VA Hospital, Pittsburgh. A palpable inguinal lymph node was excised at this time.

Second Biopsy.—Microscopic examination revealed only a few of the large tadpole- or racquet-shaped cells noted in the previous biopsy specimen. Cross striations were infrequent and recognized only in sections stained by the phosphotungstic acid hematoxylin technique. The bulk of the neoplasm was comprised of round cells with scanty eosinophilic cytoplasm and round, hyperchromatic nuclei (Fig. 2). A few larger round cells with more abundant eosinophilic cytoplasm, containing small vacuoles and centriole clusters, were also evident (Fig. 3), and in many areas these cells assumed an alveolated pattern (Fig. 4). Abundant intracytoplasmic glycogen was evident in tumor cells as diastase-labile periodic-acid-Schiff-positive granules (Fig. 5). Lipid was not apparent in sections stained with oil red O or Sudan black B. Fine reticulum fibers were apparent about individual tumor cells.

Operation.—An abdominoperineal resection was performed and was followed by a bilateral iliofemoral lymph node dissection three weeks later.

Pathological Findings: The specimen consisted of a resected portion of colon with rectum and anus attached, measuring 35 cm. in length. The entire mucosal surface of the bowel appeared intact. A nonencapsulated, poorly circumscribed mass, measuring 3 cm. in cross diameters, was present beneath the perianal skin and extended into the surrounding soft tissues (Fig. 6). Microscopic examination of many sections stained by the techniques enumerated above disclosed a picture identical with that encountered in the nodal metastasis. Neoplastic cells were principally of the round-cell type, and cross striations were not evident in sections prepared from many areas of the tumor.

Forty-three lymph nodes were recovered from the node dissection. All appeared free of tumor.

Outcome.—The patient was free of complaints for the next eight months, at which time he experienced pain in the lower right quadrant and edema of the right leg. An ill-defined, firm mass was palpable in the lower right quadrant. Despite several courses of mechlorethamine hydrochloride (nitrogen mustard), x-ray therapy, and triethylenethiophosphoramide (Thio-TEPA), the patient exhibited an ingravescent course and succumbed three years after the diagnosis of perianal rhabdomyosarcoma.

Autopsy.—The pelvis and retroperitoneal space contained large masses of firm, tan tumor. Similar-appearing nodules of variable sizes were present in the peritoneum, mesentery and omentum, lungs, liver, pancreas, vertebrae, serosa of the urinary bladder, and stomach. The right ureter was compressed by tumor at the pelvic brim and was dilated proximally. The right kidney contained several cortical abscesses.

Microscopic sections from many areas of metastases revealed areas of neoplasm similar to that described above. However, generally, nuclei were more bizarre and cross striations were extremely rare, although abortive fibrils and centriole clusters could be identified in the large, round neoplastic cells.

Fig. 6.—Macroscopic appearance of perianal rhabdomyosarcoma. The anal skin is intact except at site of biopsy.

Comment

The presence of distinct cross striations in many of the tumor cells in the initial biopsy specimen from this patient readily allows for the identification of this neoplasm as a rhabdomyosarcoma. However, their absence in subsequent specimens and many of the metastases from this patient reemphasizes the view of Stout,[8] as well as that of Horn and Enterline,[3] that the presence of such structures should not be mandatory for a diagnosis of rhabdomyosarcoma. The presence of abortive fibrils and centriole clusters in many sections which lacked distinct cross striations, features emphasized by Wolbach in 1928,[14] represent diagnostic characteristics of this type of mesenchymal neoplasm which have received insufficient attention. The lack of cross striations is also readily understood when it is appreciated that these neoplasms may recapitulate the embryogenesis of skeletal muscle, during which process such intracytoplasmic structures may not be evident.[1,15] The diverse patterns recognized in this tumor also indicate the difficulty in classifying rhabdomyosarcomas into distinct histologic types. Further, there does not appear to be any practical significance in such an exercise, since it appears that prognosis is more directly related to the site of the neoplasm and, consequently, the feasibility of aggressive surgical removal. The lack of lipid, but abundance of glycogen within the cytoplasm of the tumor cells in this case of rhabdomyosarcoma has been observed previously in this type of tumor but is worthy of reemphasis.[16] This cytochemical pattern, in our experience, has not been encountered in other neoplasms which might be histologically confused with rhabdomyosarcoma, viz., fibrosarcoma, alveolar soft-part sarcoma, malignant schwannoma of classical and epithelioid types, liposarcoma, and such epithelial neoplasms as malignant amelanotic melanoma.[17]

There have been relatively few necropsy studies performed on patients dying of rhabdomyosarcoma. Stout[8] noted only 5 of 121 cases in which widespread metastasis similar to that observed in the patient of this report was present. The more anaplastic and bizarre morphologic appearance of the metastases as compared with the primary lesion in this case is similar to the experience of others. The occurrence of nodal metastases in this case is not unusual for rhabdomyosarcoma, although such a route of dissemination is considered infrequent in malignant mesenchymal neoplasms. Involvement of an inguinal lymph node in this case is similar to that frequently noted in examples of anal carcinoma.

It is apparent that local excision in this instance did not represent adequate initial therapy. Recurrence was prompt, as is frequently observed with this type of neoplasm in other sites.[5,8] Abdominoperineal resection and ilioinguinal lymph node dissection, which was subsequently performed, would appear to represent the most satisfactory primary treatment for a rhabdomyosarcoma at this site. Survival from rhabdomyosarcoma arising in other sites without overt evidence of metastases appears to be more closely related to aggressive treatment than to other factors.[5]

The precise histogenesis of rhabdomyosarcoma has not been elucidated. Doubt has been expressed that mature skeletal muscle is capable of neoplastic transformation.[1,10] Much emphasis has been placed on the derivation of this type of malignant mesenchymal neoplasm from undifferentiated mesenchyme.[10] Nevertheless, it is quite apparent that the vast majority of rhabdomyosarcomas occur at sites in which skeletal muscles are found. The presence of the latter in the anal wall signifies such an origin in the case reported. The failure to find other mesenchymal elements than those attributable to the development of skeletal muscle in this case renders the possibility that this tumor represents a predominant rhabdomyosarcomatous growth in a mixed tumor or teratoma highly unlikely.

Summary

The clinical and pathological features of an example of a perianal rhabdomyosarcoma in a 25-year-old man are presented. To our knowledge this represents the first recorded instance of this type of malignant mesenchymal neoplasm at this site. Detailed histologic examination of this tumor and its metastases has allowed for pertinent comments concerning certain pathological features of rhabdomyosarcoma. Attention is directed to the presence of abortive fibrils and cytoplasmic glycogen as aids in its histologic identification.

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Infarction of the Entire Right Lobe of the Liver

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Infarction of the liver in the broadest sense is not particularly uncommon. Massive infarcts, however, are quite rare, and total right-lobe infarction is a distinct rarity.[1,2]

For generations there have been widespread misconceptions regarding the histologic and gross anatomy of the liver. The segmental anatomy is only recently receiving long-overdue attention in the clinical surgical literature. The monumental works of Elias [2-4] and Michels [7] have been instrumental in acquainting clinicians with the significant details which have for so long been incorrectly presented in our medical schools.

The newer concepts of the histologic anatomy of the liver is beyond the scope of this paper. The pertinent points regarding the gross and segmental anatomy, and their variance with the classical teachings are briefly reviewed here. These facts should help explain the highly variable responses elicited after hepatic artery ligation, portal vein thrombosis, portacaval anastomoses, and arterial interruptions secondary to extrahepatic procedures in the upper abdomen.

Classically, the right and left lobes of the liver are divided by the attachment of the falciform and round ligaments. However, it has been conclusively demonstrated that the true lobar division of the arterial, portal, and biliary structures is represented on the liver surface by a line extending through the middle of the gallbladder fossa, bisecting the caudate lobe, and thence up and over the dome of the "right" lobe to meet the gallbladder fossa again. The quadrate lobe belongs with the left vasculobiliary lobe. The portal triads divide and subdivide to form constant larger segments and less constant subsegments. The hepatic veins, however, do not follow parallel courses with the portal channels. More frequently they cross and interdigitate with them, welding the liver together into a unified organ. This is in contradistinction to most mammalian livers, which are grossly lobated, and whose hepatic veins parallel the portal triads. Usually there are three major hepatic veins (right, middle, and left) and a few inconstant smaller ones. Preoperative stereoscopic cholangiography can yield specific information concerning the location of portal territories.

The exact vascular, parenchymal, and bacteriologic derangements necessary for hepatic infarction are still controversial. Most investigators feel that combined arterial and portal interruption is necessary for infarction, and, in some cases, associated traumatic or bacteriologic insults.

Exact evaluation of the case reported here cannot be made, since an autopsy was not performed. However, it dramatically demonstrates the practical aspects of knowledge of the intrahepatic segmental anatomy. In addition, it again raises speculation as to the etiology of massive hepatic ischemic infarction.

Report of a Case

A 2-year-old Negro boy was admitted to Hermann Hospital on Christmas Eve, 1956. He had been struck by an automobile at 10 a. m. on Dec. 24. Examination revealed a fracture of the right

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Fig. 1.—Intravenous pyelogram taken immediately after injury. Note the distortion of the right calyceal system and the normal ureter. The patient had a complete transverse rupture of the right kidney.

humerus, multiple contusions, and a very tender right costovertebral angle. The abdomen was only moderately tender and not rigid. Gross hematuria was present. The fractured arm was splinted and immediate intravenous pyelography performed. This showed distorted calyces in the right kidney, a distinct liver border, and a normal right ureter. The left renal system was normal. The urology consultant advised conservative therapy, and the baby was put to bed.

For the first 24 hours the blood pressure varied between 110/80 and 80/60. The pulse rate tended to rise from 104 to 160. Respirations showed a slow rise from 28 to 60 per minute. The temperature varied slightly from the admission level of 100 F until about 24 hours later, when it suddenly rose to 104 F. Gross hematuria continued. An initial restlessness progressed into somnolence. Urinary output the first 24 hours was 260 cc. The hemoglobin was 12.6 gm. per 100 cc.; the hematocrit, 37%. He received 300 cc. of whole blood during the first few hours of admission. The abdomen became distended and silent, and this was attributed to the renal injury.

The second 24 hours showed no further change in blood pressure, pulse, or respiration. The temperature was remittent and varied from 104 to 100 F. Somnolence progressed to lethargy. The urine cleared somewhat, but blood was still discernible. The 24-hour urine output was 270 cc. Abdominal distention responded partially to gastric suction. Laboratory results were as follows: hemoglobin 12.0 gm. %, hematocrit 35%, BUN 54 mg. %, Cl 107 mEq/L., Na 135 mEq/L., K 6.3 mEq/L., CO_2 32 vol. %, WBC 22,500 per cubic millimeter.

The third 24 hours brought a marked increase in lethargy, which progressed to semicoma. The abdomen lost the signs of tympanites and developed those of fluid. He passed a currant-jelly stool. Right upper quadrant tenderness increased. The vital signs did not change. An abdominal roent-

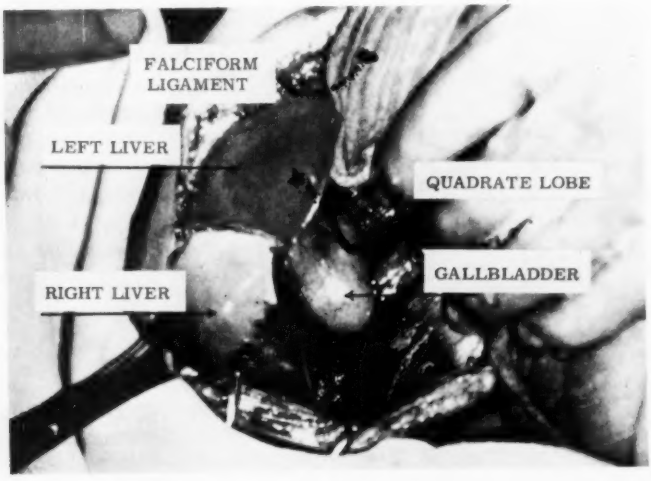

Fig. 2.—Labeled photograph.

genogram showed a haziness compatible with fluid, and the absence of free air.

The child was operated upon on the third hospital day, with the preoperative diagnosis of intraperitoneal hemorrhage or urinary extravasation. No hepatic localizing signs were present except right upper quadrant tenderness, which was not marked in view of the severe right costovertebral angle tenderness.

Operative findings were a complete transverse rupture of the right kidney and a far-advanced ischemic infarct of the right liver. The peritoneal cavity was filled with a murky fluid and numerous bits of necrotic liver tissue. A resection of the right liver was undertaken. The infarcted area peeled off the normal left liver with ease and with little bleeding. During management of the right hepatic vein, hemorrhage occurred. Technical difficulties with the cut-down were encountered at this critical time. Cardiac arrest occurred secondary to surgical and hemorrhagic shock, and, despite cardiac massage, the infant died. Postmortem examination was not performed.

Comment

Michels' book[7] beautifully illustrates the tremendous variation in the anatomy of the blood vessels in the upper abdomen. More frequently than not, there are three main divisions of the hepatic artery, rather than the classical two. Major hepatic arteries may originate from the splenic, superior mesenteric, and right gastric arteries and directly from the aorta. They frequently do not run within the gastrohepatic ligament. Variations from the classical arrangement are the rule rather than the exception.

The unpredictability of the results of the ligation of the hepatic artery and its branches is explained by these anatomic variants. In general, the farther from the porta hepatis an arterial ligation is done, the less the chance of hepatic necrosis.[10,11] Ligation of the celiac axis has resulted not in massive infarction but in widespread focal infarction.[1] The importance of the dual blood supply is brought out in the case reported by Losner et al.[6] who described massive infarction in a patient with widespread hepatic arterial emboli and simultaneous portal vein thrombosis due to cholangitis. Localio and Saltz'[5] patient evidenced massive liver destruction secondary to blunt trauma, with recovery following surgical debridement. Seventy per cent of the liver was destroyed. A later laparotomy showed a threefold increase in size of the remaining left lobe. Microscopic sections revealed the manner in increase to be due to "budding" at the periphery of the hepatic lobules. Mikesky et al.[8] encountered no such massive infarction in 300 consecutive hepatic injuries. We have encountered no reports describing such a discrete infarction corresponding to the distinct right liver. (Patel and Couinaud[9] proposed the term "right and left liver" to indicate the vasculobiliary-portal divisions and maintained the term "lobe" for the classical gross surface divisions.)

Summary

A case of discrete infarction of the entire right vascular lobe of the liver is presented. The lesion occurred after blunt trauma with associated renal injury. The importance of recent emphasis on segmental liver anatomy is stressed.

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Cholecystectomy and Its Relation to Gastric Acid Secretion

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In 1953 a study [1] of the effect of cholecystectomy upon the stomach and duodenum was carried out in an attempt to learn more about the distressing postcholecystectomy syndrome. In that investigation, 75 patients were submitted to a gastroduodenal x-ray series before cholecystectomy, and this procedure was repeated several months to two years following gallbladder removal. Although little light was shed upon the cause of the syndrome, it was demonstrated that postcholecystectomy symptoms, such as colic, belching, indigestion, and heartburn, were not associated with abnormal x-ray findings of the stomach and duodenum.

The present communication concerns itself with a further attempt to uncover more information about the pathological physiology and clinical disturbances which sometimes occur after gallbladder excision.

Persistent pain and indigestion after cholecystectomy have been attributed by Russell, Carter, Oppenheim,[2] and others to increased intraductal pressure resulting from sphincter of Oddi spasm, and they have labeled this condition hypertonic dyssynergia. These investigators felt that such spasm was due, in a large number of cases, to gastric hyperacidity and its associated duodenitis and papillitis. They also stated their belief that a large number of patients with gallbladder disease suffered from hypotonic dyssynergia and claimed that this condition was associated with hypochlorhydria. With these theories in mind, the literature was searched to discover whether studies had been made of the preoperative and postoperative gastric acid secretory levels. Since no reports of this nature could be found, and because it was thought that such an investigation might reveal interesting data, 64 patients with chronic cholecystitis and cholelithiasis were subjected to gastric analysis prior to removal of their gallbladders. These studies were then repeated some six to eight months after cholecystectomy. It was deemed best to permit an interval of several months to pass after gallbladder removal before repeating the analysis so that any temporary imbalance occasioned by the surgery would be dissipated.

The group consisted of 47 female and 17 male patients. No attempt was made to select cases other than to exclude those patients with acute inflammation of the gallbladder or bile ducts or those who had common duct stones. These were purposely excluded in order to reduce the number who might have other than their usual preoperative gastric acid readings and in order to minimize the number whose postoperative acid findings might be attributable to residual common bile duct pathology. Every patient who submitted to the preoperative and postoperative gastric analysis has been included in this series.

Standard methods of gastric analysis were employed with the passage of a Levin tube through the nose into the stomach. Fasting specimens were obtained and were examined for free hydrochloric acid, combined acid, and total acid. One hundred cubic centimeters of 7% ethyl alcohol was then given through the Levin tube to stimulate secretion, and specimens were with-

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drawn at 15-minute intervals thereafter until four specimens had been obtained. Normal ranges were considered to be those in which the free hydrochloric acid was between 25 and 50 degrees and in which the total acid was between 40 and 65 degrees. Those found to be consistently below these levels were labeled low-acid, or hypochlorhydric. Those found to be consistently above these levels were labeled high-acid, or hyperchlorhydric.

Findings

There were 29 patients with low gastric acid levels, 27 patients with normal gastric acid levels, and 8 patients with high gastric acid levels prior to operation. Twenty-four patients showed low gastric acid levels; 36 showed normal gastric acid levels, and 4 patients displayed high gastric acid levels after cholecystectomy (Table).

Gastric Acid Levels

	No. Patients
Preoperative	
Low	29
Normal	27
High	8
Postoperative	
Low	24
Normal	36
High	4

There were 11 patients in whom the gastric acid level rose from a preoperative low to a postoperative normal level. There were no patients in whom the acid level rose from a preoperative normal to a postoperative high level, nor were there any patients in whom the acid level rose from a preoperative low to a postoperative high level.

There were four patients in whom the acid level receded from a high to a normal level postoperatively, and there were four patients in whom the level dropped from a preoperative normal to a postoperative low level.

There were 45 patients in whom the gastric acid level remained approximately the same before and after cholecystectomy.

Five of the sixty-four patients, or 7.8%, were not relieved of their preoperative symptoms by the removal of the gallbladder and were therefore classified as sufferers from the postcholecystectomy syndrome. Three of these five patients were found to be moderately hypochlorhydric preoperatively, and the other two had normal preoperative gastric acid levels. All five showed levels within normal range on postoperative analysis. Thus, in none of this group of patients was cholecystectomy followed by a marked change in the level of gastric acid secretion.

Of the 64 patients, 14 (including the 5 who suffered from the postcholecystectomy syndrome) complained postoperatively of varying degrees of heartburn. No correlation between this symptom and hydrochloric acid levels was noted, inasmuch as 3 of these patients had moderately low gastric acid levels and 11 had normal gastric acid levels postoperatively. Furthermore, none of these patients showed any marked increase or decrease in their acid secretion.

Summary

Cholecystectomy does not appear to influence significantly gastric acid secretion, nor does it tend to induce either hypochlorhydria or hyperchlorhydria. Usually, as in 45 of 64 cases, the level of acid secretion remains the same.

Cholecystectomy was associated with a slight to moderate elevation of the gastric acid secretory level in 11 of 64 cases, but in no instance did hyperchlorhydria appear in a patient who had had normal secretory levels before surgery.

Of eight patients with hyperchlorhydria before cholecystectomy, four showed similar levels postoperatively, and the other four showed a tendency toward more normal acid secretion.

There were five patients who suffered from the postcholecystectomy syndrome, but none of these demonstrated any significant change in their gastric acid secretion pre- or postoperatively.

There were 14 patients who suffered from postoperative heartburn, but none of these patients showed any significant alteration in their gastric acid levels pre- or postoperatively.

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Nonchromaffin Paraganglioma (Chemodectoma) of Mediastinum

Report of Case and Review of Literature

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Nonchromaffin paragangliomas associated with the aortic bodies and located in the mediastinum are extremely rare. Lattes described the first case of human aortic body tumor in 1950.[10] Since that time a total of eight cases have been reported. The present case will be the ninth, and the first reported in a child.

The aortic bodies are only one of a group of structures which have a similar histological appearance and apparently similar physiological function. The best known of these is the carotid body, which was first recognized and described by von Haller in 1743.[5] Carotid body tumors were first reported by Marchand in 1891,[12] and have been the most commonly reported of the nonchromaffin paragangliomas.

The carotid bodies are located at the bifurcation of the common carotid arteries. Other structures of this group of organs are the glomus jugulare, located at the floor of the middle ear, associated with the ninth cranial nerve, and the ganglion nodosum of the vagus nerve, at the base of the skull.

These structures were originally classified as a group with the chromaffin tissue, which includes the adrenal medulla. However, for the following reasons, it is now believed that they should be grouped separately: 1. They do not secrete epinephrine. 2. They do not yield a true chromaffin reaction. Cells of the chromaffin system contain granules which stain a yellow-brown when fixed in chromate salts. 3. They have an afferent, sensory-type innervation, whereas the chromaffin organs are motor in innervation. 4. They arise from neural primordia, or *Anlagen*, in close association with peripheral vessels. 5. They function probably as chemoreceptors responsive to alterations of pH or carbon dioxide concentration of the blood.[5]

The aortic bodies have been shown by several investigators to be at least four in number and to occur in the following locations: (1) near the innominate artery, either near its bifurcation into the subclavian and common carotid arteries or lateral to the origin of the subclavian artery; (2) on the anterolateral aspect of the left portion of the aortic arch near the origin of the left subclavian artery; (3) near the pulmonary end of the obliterated ductus arteriosus, and (4) near the origin of the left coronary artery. This location is somewhat inconstant.[1,3,6,15]

The exact embryonic origin of these bodies is not clear. They are probably derived from neural elements predominantly vagal in origin and mesenchymal elements related to the fourth and sixth branchial arches.[4]

Report of Case

The patient, a 13-year-old Caucasian boy, was admitted to the Indianapolis General Hospital on Oct. 19, 1957, for observation of a possible traumatic rupture of the spleen as a result of an injury sustained by jumping from the top of a railroad box car one day prior to admission. At the time of admission he complained of abdominal pain, present since the time of injury. There was also a complaint of mild abdominal distention.

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From the Departments of Surgery and Pathology of the Indianapolis General Hospital.

The past history was noncontributory, with a normal childhood development. He had had a mild attack of poliomyelitis at the age of 4 years, with no apparent residual effects. There is no history of a previous chest x-ray.

Physical examination showed a well-developed, well-nourished male child in no acute distress. The admitting blood pressure was 110/80, the pulse rate 100, and the respiratory rate 16-20, a minute. The eye, ear, nose, and throat examination was negative. The lungs were clear to auscultation and percussion. The heart was not enlarged. There was a Grade 2 systolic murmur heard in the right aortic area with transmission into the great vessels of the neck. There was also a systolic thrill in the apical area. The abdomen was slightly distended. There was no tenderness. The tip of the spleen was thought to be palpable just below the left costal margin. No other organs or masses were palpable. Bowel sounds were normal. Rectal examination revealed a small rectal polyp. The remainder of the physical examination was negative.

On admission the hemoglobin was 9.4 gm. per 100 cc., with a white blood cell count of 9000 per cubic millimeter. The differential count was as follows: neutrophils, 55%; band forms, 8%, and lymphocytes, 37%. This remained essentially the same on repeat blood counts. Urinalysis showed a specific gravity of 1.014 and was completely negative. An amylase level of blood drawn on admission was 50 Somogyi units.

A routine posteroanterior chest x-ray showed a mass in the right mediastinum. Repeat chest films localized the mass to the right posterior mediastinum, and the radiologist's impression was that of a neurofibroma (Figs. 1 and 2).

The remainder of the work-up included an EKG, which was interpreted as within normal limits. The patient was transfused with 500 cc. of whole blood on Oct. 30.

In view of the x-ray findings, it was felt that an exploratory thoracotomy was indicated, and the patient was taken to surgery three weeks after admission. A thoracotomy was performed under nitrous oxide, thiopental (Pentothal) sodium, and succinylcholine (Anectine) anesthesia. Induction of anesthesia was normal. The child was placed in the left lateral position, and a right thoracotomy incision was made without incident. As the pleural cavity was entered, and before the tumor was visualized, a large amount of serous bloody fluid exuded from the endotracheal tube, and at this point it was felt that the procedure would have to be abandoned. However, a needle was inserted into the mediastinal mass in an attempt at aspiration, and a small amount of grossly bloody fluid was obtained. Owing to the difficulty in maintaining an adequate airway because of the profuse flow of fluid from the endotracheal tube, the right

Fig. 1.—Posteroanterior chest x-ray, showing the tumor mass protruding into the right thoracic space.

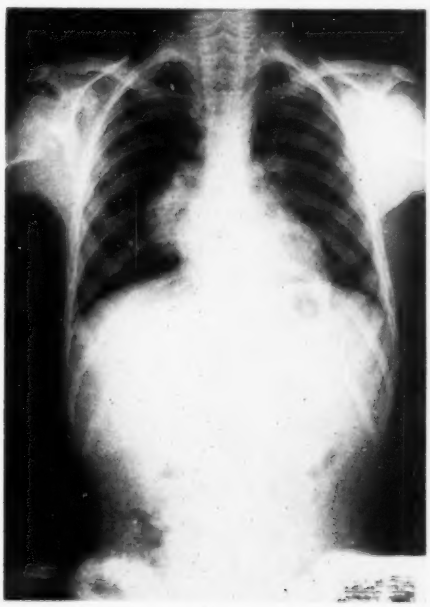
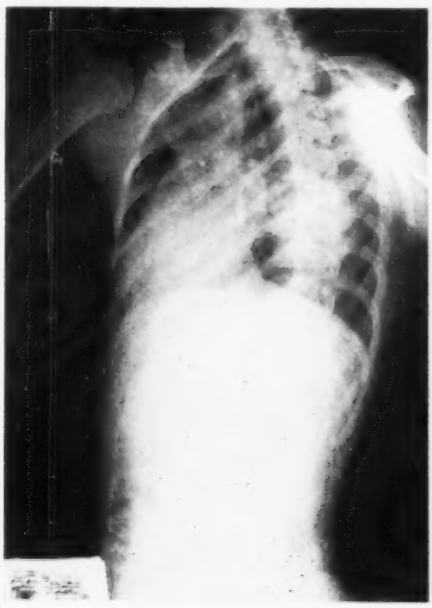


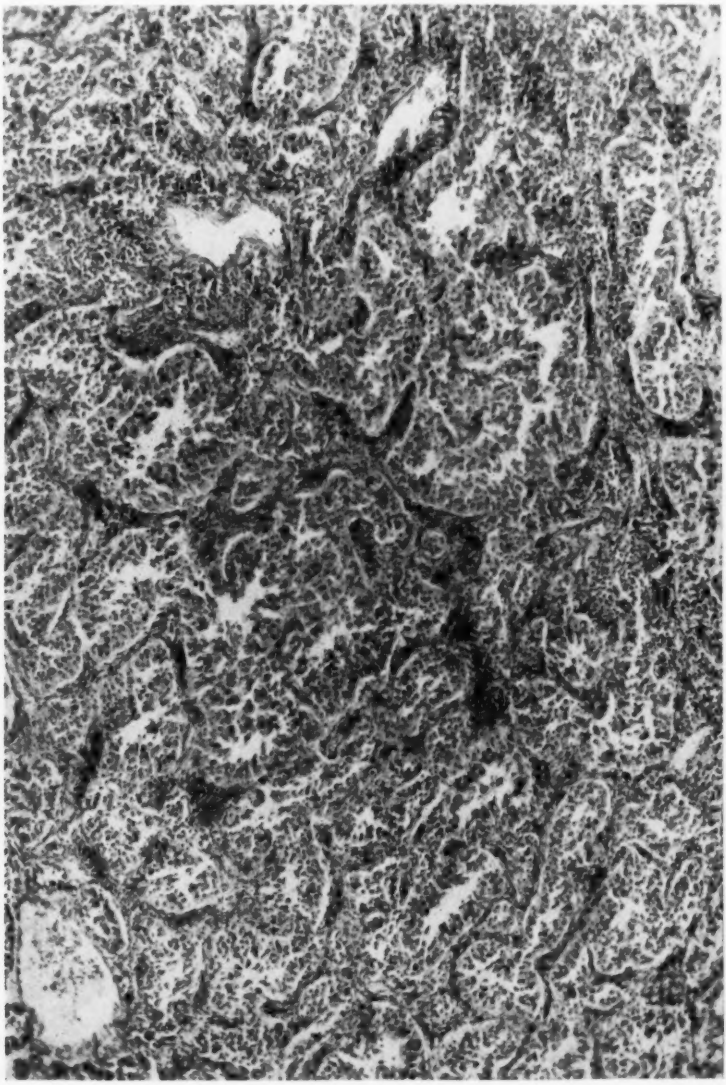
Fig. 2.—Right oblique chest x-ray, showing tumor mass in the posterior mediastinum.



chest was closed with a thoracotomy tube in place. The child was then placed in the prone position and further unsuccessful attempts to clear the airway made. At this point cardiac arrest occurred, and the child was successfully resuscitated through a left thoracotomy incision, with maintenance of a systolic blood pressure of 60 mm. Hg. Respirations were also spontaneous at this time, although it was still not possible to keep the airway cleared of the edema fluid. A second cardiac arrest occurred within an hour, and resuscitation was unsuccessful.

Autopsy.—Gross Findings: Abnormal findings were confined to the thoracic cavity. External examination showed recent bilateral thoracotomy incisions. Examination of the right posterior mediastinum revealed a firm, smooth mass, measuring 7×5 cm. and protruding into the pleural space for 3 cm. The mass was located at the costo-

Fig. 3.—Photomicrograph of tumor, showing the arrangement of cells in nests surrounded by connective tissue trabeculae. × 100.

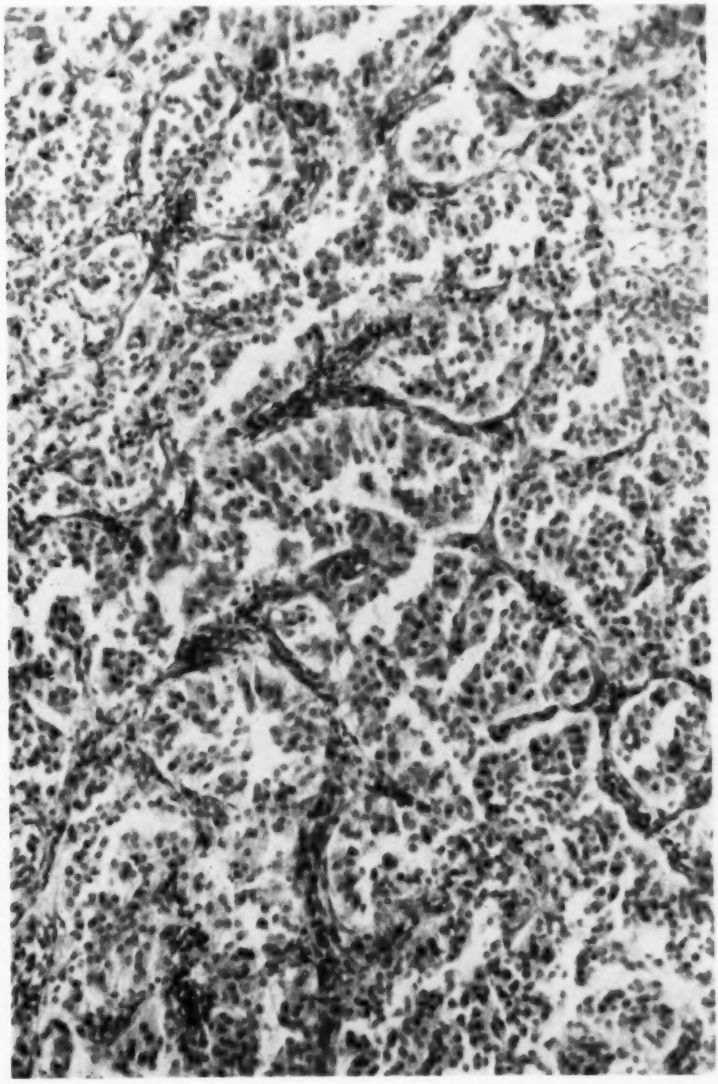


vertebral junction at the level of T-6. It was firmly adherent to the vertebral column and appeared to be well encapsulated and covered by parietal pleura. There were small areas of hemorrhage on the surface. The mass weighed 60 gm. and on cut section was a light tan in color with areas of hemorrhage.

The left lung weighed 440 gm., and the right lung 390 gm. The bronchi and trachea were filled with a frothy, thin, bloody fluid. The lungs did not appear abnormal on external examination. On cut section the lung parenchyma appeared dark red in color with frothy, bloody fluid extruding from the cut surface.

Microscopic Examination: The lungs showed subpleural petechiae. The alveolar spaces were filled with blood and edema fluid.

Fig. 4.—Photomicrograph of tumor showing cell nests with round or ovoid nuclei. Some of the nuclei are hyperchromatic and are fairly uniform in size. Connective tissue trabeculae contain vascular channels. × 450.



The tumor was well encapsulated. It was composed of cells with moderately abundant eosinophilic cytoplasm, which did not appear vacuolated. The cells were generally arranged in nests, surrounded by a fine network of connective tissue trabeculae. The nuclei were round or ovoid and fairly uniform in size. There were frequent hyperchromatic nuclei, with occasional bizarre nuclei present. Some of the larger cells contained large nuclei with nucleoli within them. In areas the general structure had an organoid appearance. There were vascular channels in moderate amounts in the connective tissue. In some areas there was hemorrhage; these areas, in correlation with the gross findings, appeared to be the sites of needle puncture at the time of surgery (Figs. 3 and 4).

Repeated attempts were made in our laboratory and at the Institute of Cancer Research at Columbia University[16] to find chromaffin granules, in an attempt to explain the mechanism of death secondary to a functional tumor. We have been unable to show chromaffin granules by various techniques.

Microscopic examination of the other body tissues showed no abnormalities.

Comment

There have been eight previously reported cases of nonchromaffin paragangliomas located in the mediastinum (Table). The present case is the ninth. To date, there has been no report of this tumor arising in a person as young as the present patient. There have been two previous cases in which the tumor has been located in the posterior mediastinum, and, like the present case, they were located on the right side.

In all these cases except those of Duncan and McDonald and the present case the tumor has been located in the anterior mediastinum and in relation to the anatomical location of the aortic bodies. In the two cases of Duncan and McDonald the tumors apparently were located in close relation to the descending aorta and, although aortic bodies have not been anatomically identified in this area, it is postulated that the tumors may have arisen from small collections of chemoreceptor cells located in the adventitia of the aorta.[8] The tumor in the present case grossly had no connection with the aorta, and we feel that it may have arisen as a growth from the right vagus nerve or one of its branches.

The tumor clinically is usually asymptomatic and has most commonly been found either on routine x-ray of the chest or at autopsy.

The gross and microscopic features of all the reported aortic body tumors are essentially the same, and closely resemble those of the carotid body tumor. Grossly aortic body tumors are well encapsulated, and the capsule may be densely adherent to the wall of a large blood vessel, making resection impossible. The microscopic appearance is characteristic. The basic pattern is one of nests of large epithelioid cells surrounded by vascular channels. Architecturally, the tumors may vary from an "adenomatous" form, in which the epithelioid cells predominate, to an "angiomatous" structure, in which the vascular channels are more obvious.[13] The pattern is less bizarre than that found in the chromaffin tumors.

Therapy depends on the features of close adherence to large vessels and to the amount of local invasiveness. The aortic body tumor is apparently resistant to radiotherapy.

Summary of Reported Cases

Author	Date Reported	Sex	Age	Symptoms	Location
Lattes	1950	M	59	Mass in neck	Ant. sup. mediastinum
Lattes	1950	M	35	Inoperable ganglion nodosum tumor	Obliterated ductus arteriosus
Monro	1950	M	22	Mass in neck	Ant. sup. mediastinum
Duncan & McDonald	1951	M	18	Routine x-ray	Rt. post. costovert. sulcus; level 9–11 ribs
Duncan & McDonald	1951	F	33	Routine x-ray	Rt. post. costovert. sulcus; level T-7 vertebra
Davies & Randall	1954	F	67	Incidental finding at autopsy	Rt. auricular appendage
Mendelow & Slobodkin	1957	F	31	Routine x-ray	Rt. ant. sup. mediastinum
MacDonald	1957	M	79	Incidental finding at autopsy	Left subclavian artery distal to thyrocervical axis
Taylor & Evans	1958	M	13	Routine x-ray	Rt. post. costvert. sulcus at level T-6

as are the other nonchromaffin paragangliomas.[13,14] In most cases complete removal is not possible, owing to local invasiveness or adherence to large vessels. From the reported cases, it would seem that, even though the tumor cannot be completely removed, it may not be incompatible with long life, since most of the tumors have been observed in elderly people as an incidental finding at autopsy or as a finding on routine chest x-ray.

We are unable to explain the exact mechanism of death of our patient. However, we feel that the tumor was nonfunctional and that the copious amount of hemorrhagic pulmonary edema that occurred cannot be explained on this basis.

Summary

A case of nonchromaffin paraganglioma of the mediastinum is reported. This is the ninth such tumor to be found in the mediastinum, the third in the posterior mediastinum.

The literature is briefly reviewed and a summary of the reported cases made.

Aortic body tumors closely resemble the other nonchromaffin paragangliomas in microscopic appearance.

Aortic body tumors probably are not incompatible with long life.

Dr. Arthur Purdy Stout, of the Institute of Cancer Research, Columbia University, reviewed the tumor sections and made special chromaffin stains. Robert Albright made the photomicrographs.

960 Locke St.

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Villous Papilloma of the Rectum with Severe Fluid and Electrolyte Depletion

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It is generally conceded that carcinoma of the rectum is best treated by surgical extirpation. Treatment by irradiation is occasionally advocated for lesions believed to be of low malignancy. Though popular in some foreign clinics, this modality is rarely used in the United States because many patients develop a severe proctitis, producing disabling symptoms for a prolonged period. Recently we had occasion to treat one patient by radium who refused surgical extirpation of his lesion. Two years later a severe electrolyte imbalance developed that was attributed to irradiation proctitis. In view of the recent report by Starr and his associates of a case of "villous adenoma" of the colon associated with severe hypopotassemia,[1] the question of the possibility that the electrolyte imbalance might be a complication of the primary lesion was raised.

Report of a Case

A 56-year-old white man was admitted to the Veterans' Administration Hospital, Houston, Texas, in October, 1953, stating that a large "adenoma" of the rectum had been treated by fulguration in 1944. Following treatment, he remained asymptomatic until 1951, when intermittent episodes of mucoid stools, with bright red blood, were noted. These symptoms persisted during the intervening two years, until the time of admission. Physical examination revealed a polypoid mass in the rectum. On proctoscopic examination a "polyp," 5 cm. in diameter, appeared to be the source of bleeding. In addition, there was a villous neoplasm involving the entire circumference of the rectum from the dentate line to a distance of 11 cm. An air-contrast barium enema failed to disclose polyps above this level. Multiple biopsies failed to confirm a diagnosis of carcinoma; therefore, the largest polypoid mass was excised under spinal anesthesia, and an attempt was made to fulgurate the remainder of the lesion. Treatment was unsuccessful because of the size of the tumor. The patient was advised to have excision of this portion of the rectum with preservation of the anal sphincter. He said, however, that excision of the tumor had relieved his symptoms, and he refused further surgical intervention.

Following discharge from the hospital he remained essentially asymptomatic, but he returned regularly for follow-up examinations. In January, 1954, a biopsy specimen revealed columnar-cell carcinoma, and at this time abdominoperineal resection was advised. The patient again refused surgical therapy, but continued to return for follow-up examinations, and his problem was discussed periodically in the Tumor Clinic until July, 1954. At that time, in view of his repeated refusals to undergo resection, treatment with a radium mold was suggested as a possible alternative. This therapy was instituted on July 26, 1954. Tubes containing 25 mg. of radium distributed evenly over a distance of 15 cm. with 5 mm. Pt filtration were constructed. A tube was inserted into the rectum for six and one-fourth hours daily for five consecutive days, to deliver a total dose of 4000 r. There were no undesirable side-effects during the course of treatment, and in August, 1954, a proctoscopic examination revealed a decrease in the number and size of the polyps. However, in October, 1954, a marked skin reaction developed, which increased in intensity until inflammatory changes involved approximately one-half of the buttocks bilaterally. Because of the extreme pain associated with the examination, proctoscopy was not attempted again until December, 1954, and at that time only after heavy sedation. Examination of the entire rectum was not satisfactory, but an ulceration was observed in the anal canal. Repeated periods of hospitalization were necessary during the succeeding five months because of persistent pain due to radiation reaction.

In May, 1955, proctoscopic examination again revealed the ulceration of the anal canal, in ad-

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From the Cora & Webb Mading Department of Surgery, Baylor University College of Medicine, and the Departments of Surgery and Pathology, Veterans' Administration Hospital.

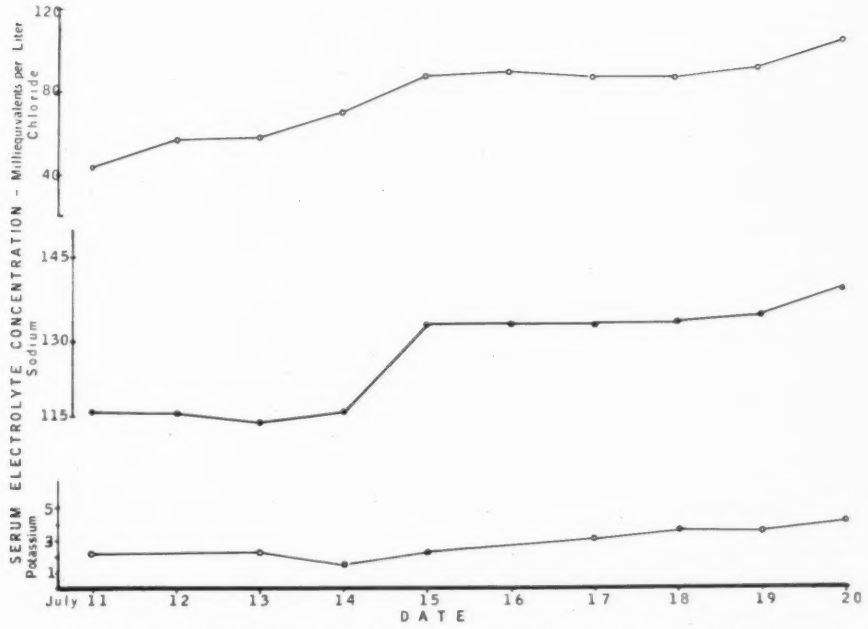

Fig. 1.—Graph showing the serum electrolyte concentrations at the time of admission and the progressive rise to normal during the period of treatment.

dition to marked erythema of the rectum. There were many "polyps" still remaining, and a biopsy of one of these again was interpreted as showing carcinoma. During the ensuing two months the anal sphincter became fibrotic and the acute inflammatory process subsided. Frequent involuntary discharges from the rectum were noted. This condition improved, so that by July, 1955, he stated that he had good bowel control when the stools were formed. Proctoscopic examination at this time revealed no change. When next seen, in January, 1956, he complained of increasing drainage per rectum, so that it was necessary to wear rubber pants and to change a rectal pad three times daily. Proctoscopic examination again revealed no change in the appearance of the rectum.

He was next admitted to the hospital in July, 1956, complaining of weakness, malaise, and a 15-lb. weight loss during the past three weeks. Physical examination was essentially unchanged except for evidence of severe weight loss and dehydration. There were marked alterations of serum electrolytes, the serum chloride concentration being 44 mEq/L., the serum sodium 118 mEq/L., and the serum potassium 2.2 mEq/L. The carbon dioxide-combining power was 31 mEq/L.; BUN, 91 mg. %; hemoglobin, 18.5 gm. %, and total protein, 6.9 gm. % (Fig. 1). Measurement of the rectal discharge disclosed a variation in quantity from 1500 to 2000 ml. per day, with a sodium concentration of 122 mEq/L., a chloride concentration of 130 mEq/L., and a potassium concentration of 38.5 mEq/L. The protein loss was up to 5 gm. per day. He was given intensive fluid and electrolyte replacement. The electrolyte concentrations returned to normal levels, and the patient improved subjectively. Abdominoperineal resection was again urged, though he again refused and left the hospital with dietary instructions designed to maintain his electrolyte and fluid balance. Readmission was necessary two weeks following discharge. At this time the serum chloride was 64 mEq/L., sodium 127 mEq/L., and potassium 2.2 mEq/L. The rectal drainage was essentially unchanged. The fluid and electrolyte imbalance was again corrected, and the patient agreed to submit to abdominoperineal resection, which was performed on Sept. 13, 1956.

At the time of operation there was evidence of irradiation reaction only in the anus and lowermost portion of the rectum, where ulceration was present in the region of the dentate line. The anal sphincter and the levator muscles were quite fibrotic, and there was scarring of the perianal skin. There was no evidence of intra-abdominal spread of the neoplasm.

The pathologic specimen (Fig. 2) consisted of the sigmoid colon, rectum, and anus, 24 cm. long,

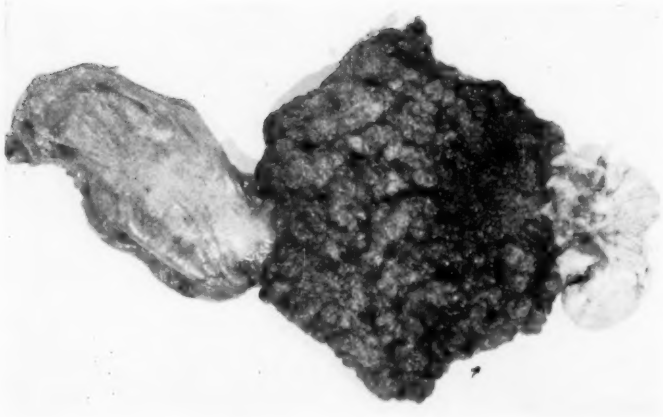

Fig. 2.—Gross appearance of the surgical specimen. The circumference of the rectal lumen is replaced by friable villous neoplasm. There is a small ulceration at the dentate line.

and another portion of colon 15 cm. long. The lining of the anal canal was yellow-gray and slightly eroded. Immediately above the anal canal the entire circumference of the lumen was replaced by a friable villous neoplasm over an area 18×13 cm. The villous projections were delicate and closely spaced and broke readily. On the cut surfaces the pattern of outer muscle coats was well defined. In the subserosal adipose and connective tissue eight lymph nodes were located. Their gross patterns were preserved. Microscopic examinations (Figs. 3A and 3B) revealed that one surface was covered with tall columnar mucus-secreting cells, which dipped to line large crypts. These were contiguous with even taller neoplastic columnar cells, mounted on delicate connective tissue stalks. The neoplastic cells were crowded, and in places the nuclei were heaped several rows deep. The nuclei stained deeply, and some were in a state of division. The neoplastic columnar cells were goblet cells, containing varying amounts of secretion. The papillary projections frequently formed variegated folds. The delicate tunica propria was infiltrated with plasma cells and some lymphocytes, large mononuclear cells, and a few neutrophilic granulocytes. The neoplastic cells extended to the muscularis mucosae, but nowhere extended into it.

The microscopic diagnosis of "papilloma, villous, with in situ malignant change" is more appropriate than the assumption that the deeply stained large cells are cancer cells. Invasion, an essential feature

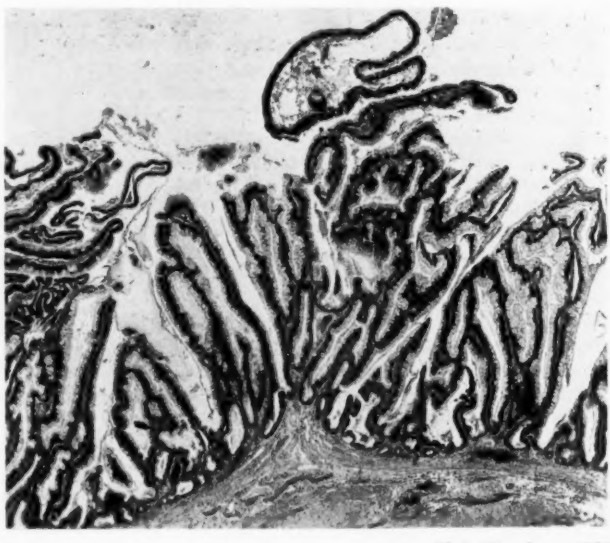

Fig. 3A.—Microscopic appearance of tumor (× 20). Delicate villous projections are covered with tall columnar mucus-secreting cells, nowhere extending into the muscularis mucosae.

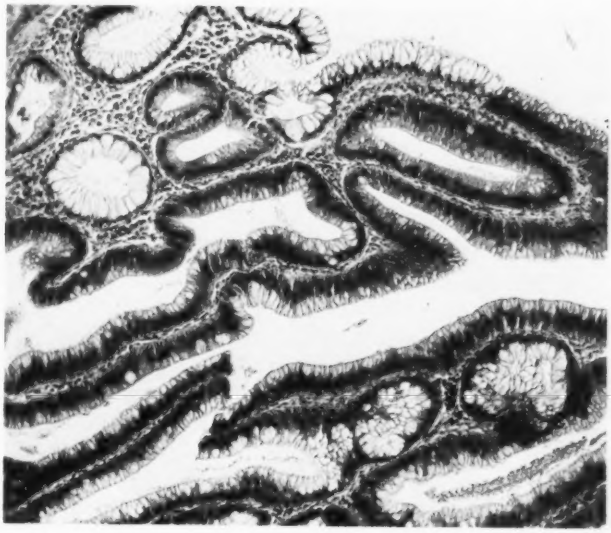

Fig. 3B.—Microscopic appearance of tumor (× 100). Tall columnar mucus-secreting cells are contiguous with cells having larger, more deeply stained nuclei, crowded together, with some in a state of division.

of malignant growth, was not observed, as indicated by the lack of infiltration of the cells into and past the muscularis mucosae. Nevertheless, the increased size of the neoplastic cells, the hyperchromatism of their nuclei, and their crowding and frequent division indicate growth activity.

The postoperative course was uneventful. Within two weeks the patient was able to train his colostomy to respond once daily to irrigation. The perineal wound healed slowly. The patient is now alive and well 15 months after operation.

Comment

This neoplasm falls into the classification of villous papilloma with in situ malignant change. These tumors grow slowly and remain localized several years without spreading upward in the colon or to distant sites. Whether irradiation inhibits the growth in any way cannot be stated; however, the microscopic appearance disclosed no significant change.

The area of irradiation reaction was too small to account for the massive fluid and electrolyte loss which was encountered. Careful pathologic examination demonstrated the presence of innumerable actively secreting goblet cells, which, in our opinion, constituted the source of the rectal discharge. The discharge was clear, without bile or feces, and had the appearance of a secretion rather than that of normal bowel content. As noted, the electrolyte concentration was particularly high for secretion in this part of the gastrointestinal tract, especially with regard to potassium and chloride. The electrolyte loss gradually produced a state of depletion greater than we have previously encountered in a patient who survived. It is interesting that it was this complication that led the patient to accept surgical management rather than his fear of malignancy. It appears that the primary reason for consistent refusal to accept abdominoperineal resection was the fear of the establishment of a colostomy. This fear was so strong that it resulted in adamant refusal of surgery until fear of immediate death from fluid and electrolyte loss became greater. Fortunately, since operation the management of the colostomy has been very simple, and the patient has learned that it is possible to live a normal life after having the rectum removed.

Summary

A case of villous papilloma of the rectum, with in situ malignant change, is reported. Treatment with radium mold was followed

by development of irradiation proctitis. Later on, fluid and electrolyte imbalance occurred, which we believe was a complication of the primary tumor rather than a complication of treatment. The patient is well, 15 months after abdominoperineal resection.

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Experimental Study of Hemostatic Ligature Techniques of Arteries in Dogs

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Safe ligature of large arteries may present a major problem during surgery, particularly if the segment available for tying is a short one. The slipping of sutures and retraction of the transected vessel are the main difficulties encountered. A perusal of the literature shows that little experimental work has been reported on this subject. We have investigated the mechanical problem of hemostasis with particular attention to the technique of ligaturing, as well as the minimum length of vessel which may be left behind and still have safe and adequate control of bleeding.

Method

Experiments were carried out on healthy mongrel dogs utilizing thiopental (Pentothal) anesthesia. Arteries of various diameters were selected, and for purposes of presentation they are divided into three groups: (1) moderate-sized systemic arteries (superior and inferior mesenteric and common iliac arteries); (2) large, thin-walled intrathoracic arteries (pulmonary artery and left brachiocephalic artery), and (3) large, thick-walled artery (descending aorta). In all these animals systemic pressure was monitored through either the opposite femoral or the internal mammary artery, and in experiments involving ligature of the pulmonary artery, pressures were also obtained from the right ventricle by means of a plastic cannula inserted through the right auricular appendage. The animals were given heparin so as to prevent coagulation of the blood, and tourniquets were placed loosely around the vessels proximal to the site of intended ligature and division in order to control hemorrhage if the ligature to be studied were to slip off. Peripheral blood pressures were lowered to 60 mm. Hg by draining arterial blood from the animal into a reservoir. Elevations of blood pressure were accomplished by the returning blood from the reservoir or by the use of vasopressor drugs so as to raise the blood pressure in the systemic arteries to ranges of 160-240 mm. Hg and in the pulmonary artery to levels from 40-100 mm. Hg. The diameter of the arteries and the thickness of their walls after division were measured. The vessels were ligated with the following diameters of silk suture: 000, 00, and 0. The techniques for applying the ligature were as follows (Figure):

1. A free tie with a square knot
2. Free tie with surgeon's knot
3. A "stick-tie," in which the needle caught the wall of the vessel at two opposite points of the wall without entering the lumen and the ligature was tied with a square knot
4. A transfixing suture, in which the needle penetrated the lumen in its midpoint and emerged on the opposite side, with completion of the suture application by means of a square knot.

The ligatures were tied as securely as possible without breaking the suture of a given size. We tried to effect hemostasis with a suture of the smallest possible diameter at the initial try. The vessels were

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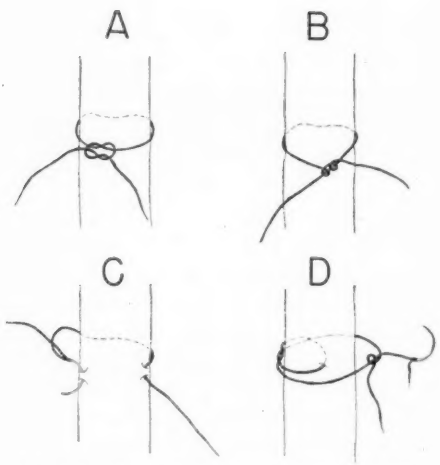

Ligature-application techniques utilized in study. *A*, "square" knot; *B*, surgeon's knot; *C*, "stick-tie," or stitch, ligature; *D*, transfixion suture.

then divided with vascular scissors at various measured lengths distal to the ligature. The ligature was tested at low and normal blood pressures, and if it was secure, the blood pressure was then raised to higher levels by the methods described above. In each experiment the arteries were ligated and divided repeatedly under varying conditions as long as the blood pressure could be altered. In all, 86 observations were made on 12 animals.

Results

Group I (medium-sized systemic artery).—In 18 observations in this group all arteries could be securely tied with 000 silk, and all of them held tightly at low and high pressures with a segment as short as 1 mm. distal to the ligature. The type of suture technique did not appear to make any difference. Elevations of peripheral blood pressures to 240 mm. Hg were tolerated without difficulty. In this group, when the length of the transected vessel distal to the ligature was reduced to 0.5 mm., there was slippage of the ligature in all instances either at normotensive or at hypertensive levels. Transfixion ligatures, however, held securely twice, whereas on two other occasions this type of ligature also slipped. The thickness of the walls of the vessels in this group ranged up to 0.5 mm.

Group II (large, thin-walled intrathoracic vessels, pulmonary and brachiocephalic arteries).—In 26 experiments in this group, with a vessel segment of 1 mm. or longer, all ligature techniques appeared to be satisfactory, and no leaking or slipping of suture occurred at low or high arterial pressure. When the length of the stump was reduced to 0.5 mm., all techniques for ligation, with the exception of the transfixion-suture method, were unsatisfactory. On two occasions the transfixion ligature held, whereas two other times it did not. The walls of the vessels in this group were thin, being less than 0.5 mm. in thickness.

Group III (descending aorta).—We were dealing with a large, thick-walled intrathoracic vessel. The diameters varied from 10 to 22 mm. and the wall thickness from 0.75 to 2 mm. Sutures of 000 silk were not strong enough to permit approximation of the walls. On only three occasions could 00 silk be used safely. In all remaining experiments it was necessary to use 0 silk. With a transected segment of 1 mm., all techniques failed to give safe hemostasis in 12 attempts, except once after a free tie with a square knot and twice after transfixion ligatures had been applied. In 5 out of 14 experiments a 2 mm. segment could be left safely (in 3 after a free tie and in 2 after a stick-tie); the rest of the time leakage and slipping of the ligature occurred. With a 3 mm. segment in 15 experiments all ligature techniques were satisfactory except once, when an extremely thick, wide aorta (diameter 22 mm. and wall thickness 2 mm.) could be handled safely only when a 4 mm. stump was left. It was further noted that ligation and division could be carried out more safely when the adventitia was left on the aorta. Without this tissue, the ligature tended to cut through. The adventitia also seemed to help anchor the tie and prevent slipping.

Comment

A careful evaluation of our results shows a correlation between the thickness of the vessel wall and the length of vessel segment that had to be left in order to effect safe hemostasis. When the length of the stump distal to the ligature was twice the thickness of the vessel wall, safe hemostasis could be effected even at hypertensive levels, regardless of the ligature technique used. The diameter of the vessel itself did not seem to be of great importance. When large, thin-walled vessels, such as the brachiocephalic and left pulmonary arteries, with walls less than 0.5 mm. thick, were tied and a segment as short as 1 mm. left, the ligature held, whereas when aortas of smaller diameter were so handled, safe hemostasis could not be brought about because the vessel walls were much thicker.

An analysis of ligature techniques revealed little difference in the free tie utilizing a square knot, a surgeon's knot, and the "stick-tie." After transfixion suture, however, the vessel segment could, on a number of occasions, be left shorter and still have the ligature hold. This, however, was not consistent.

In applying these findings to man, it would seem that, wherever possible, the length of the vessel stump should be at least two times that of the thickness of the vessel wall. Greater lengths, of course, are desirable whenever possible; shorter segments than this cannot, in all likelihood, be safely handled consistently. This latter point is particularly important when the ligature is being applied while the patient is hypotensive. When normal blood pressure is regained, the suture, which appears safe at hypotensive levels, is liable to slip if the length of vessel distal to the tie is not sufficiently long.

The thickness of a vessel wall can be determined at the time of surgery by inspection and palpation of vessels, as well as observation of similar vessels in the area which have already been safely transected. The past experience of the surgeon will also permit him a reasonably accurate estimation of the wall thickness of the vessel he encounters. Since these studies were carried out in dogs without significant arteriosclerosis, the role of this type of vessel-wall change could not be evaluated. Insofar, however, as it causes increased thickness of the vessel wall, as well as increased brittleness, it would seem that even greater lengths of vessel wall should be left to effect safe hemostasis. As to the technique of ligature application, where only minimal lengths of vessel distal to a tie can be obtained, it would appear that the safest type is the transfixion-suture ligature.

Summary

Studies have been carried out on factors influencing safe ligature of arteries. The diameter of suture, the technique of ligature, the diameter of the vessel, the thickness of the vessel wall, the length of vessel distal to the tie, and the effect of altering blood pressure have been studied.

Hemostasis could be effected satisfactorily at normotensive and hypertensive levels only when the length of segment distal to the ligature was twice the thickness of the vessel wall, regardless of the diameter of the vessel and the technique utilized for effecting the hemostasis. At hypotensive levels, shorter segments of vessels could be secured temporarily; but when the pressure became elevated, the ligatures almost invariably failed to hold unless the vessel length distal to the ligature was equal to or exceeded twice the thickness of vessel wall.

Of all ligature techniques cited, transfixion suture appeared most satisfactory, for it held securely when adequate lengths of vessel were left; but, in addition, it proved effective at times on shorter vessel stumps when the other techniques failed.

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Treatment of Patients with Acute Perforation of Peptic Ulceration

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Interest and controversy in the treatment of patients with perforated peptic ulcer have been reawakened by the suggestion of, first, nonoperative treatment of such patients by suction and antibiotics, and, second, by primary gastric resection[1,2,8] to replace simple operative closure. In an attempt to evaluate these suggestions, a review of 98 patients with perforated peptic ulcer seen at the Milwaukee County Hospital in the 60 months from Jan. 1, 1951, to Dec. 31, 1956, was undertaken.

The youngest was 23 and the oldest 83 years of age. Fifty-three per cent were 50 years of age or older (Fig. 1). Of the patients 79% were men and 21% were women (Fig. 2). Seventy-six ulcers were reported as duodenal, and twenty-one as gastric, by the operating surgeon. In addition, there were two free perforations of jejunal ulcers which occurred subsequent to perforation of a duodenal ulcer and gastric resection or posterior gastroenterostomy. However, scar contracture may make ulcers appear to be on the gastric side of the pylorus when, in fact, they are duodenal in origin. The average age of our patients, all of whom were charity patients in a county hospital, was higher than that reported in many other series, and the proportion of gastric ulcers (Fig. 3) was higher. Both female patients and duodenal ulcers have a high mortality rate[9] (Figs. 4 and 5).

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From the Department of Surgery, Milwaukee County Hospital.

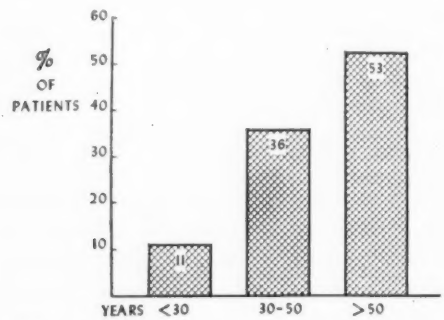

Fig. 1.—Percentage of patients in the various age groups with acute perforation of a peptic ulcer.

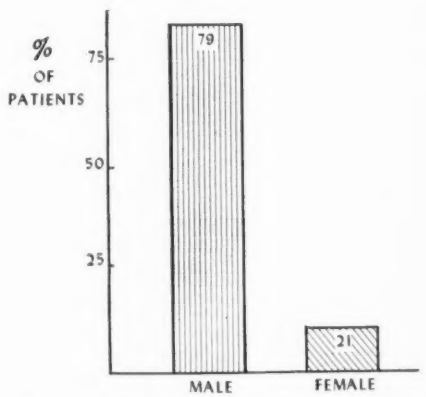

Fig. 2.—Sex distribution of patients with acute perforation of a peptic ulcer.

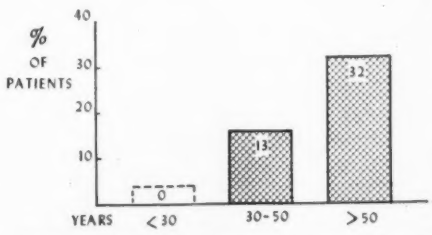

Fig. 3.—Relative incidence of acute perforation in gastric ulcers in various age groups.

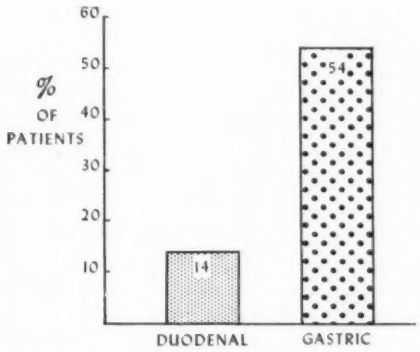

Fig. 4.—Comparative mortality rate in acute perforations of duodenal and of gastric ulcers.

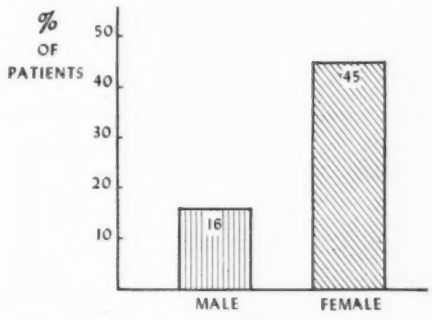

Fig. 5.—Comparative mortality rate by sex in patients with acute perforation of a peptic ulcer.

The signs and symptoms encountered in this group were similar to those reported elsewhere, with the exception of massive hemorrhage, which occurred coincident with perforation in one case and in the immediate postoperative period in nine, or in a total of 10%. This is higher than the percentage usually given.

Of those patients whose condition permitted careful interrogation, roughly four out of five gave a history of digestive symptoms consistent with peptic ulceration. In half this number symptoms were of short duration, and, in many instances, this history was not obtainable until after surgery.

Air beneath the diaphragm was demonstrated by x-ray examination in proportion to the time elapsing between onset of symptoms and examination; i. e., the longer the interval the greater the number showing free air. Parenthetically, demonstration of air beneath the diaphragm is not essential in the diagnosis of perforated peptic ulcer. Two unhappy experiences in this series were directly attributable to reluctance on the part of the examining physician to make the diagnosis of perforation in the absence of free air, with death in one instance and great morbidity in the other.

Seven of the patients with perforation of a peptic ulcer entered the hospital drunk, disorderly, or disoriented, usually all three, and perforation was not suspected prior to autopsy. Another patient entered the hospital in extremis, a condition which was recognized as being caused by perforation of a peptic ulcer, and died 35 minutes later. Fourteen additional patients entered the hospital with signs and symptoms of shock, i. e., tachycardia, with a rate of over 140, and hypotension, with a pressure of less than 100 systolic. In three of these patients surgery was deemed unwise, and in another it was abandoned shortly after entering the abdomen because of the patient's general condition. All four died. Two of these patients had perforation of gastric ulcers in the hospital, undergoing treatment for

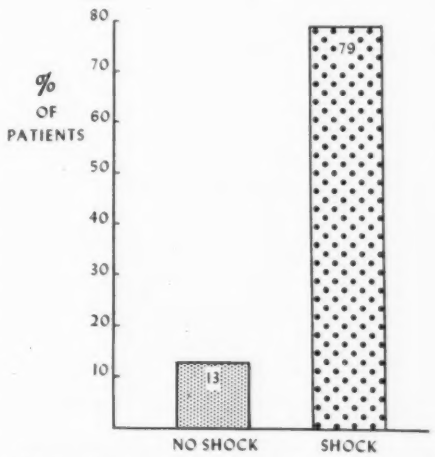

Fig. 6.—Mortality rate as influenced by systemic condition (shock) on admission.

pyloric obstruction. Resection was attempted in each, and both patients died. Of the total group of 14 patients who were in shock on admission, 11 died, or a mortality rate of 79% (Fig. 6).

The prognosis was found to be influenced by the same factors found of significance in other reports; particularly, time elapsed prior to institution of treatment, errors in diagnosis (almost all of which were unavoidable, due to the patient's condition upon admission), and *age*. There was only one death in patients operated upon within eight hours of perforation, and only one death in patients less than 50 years of age, regardless of the interval between perforation and hospitalization and/or treatment—the patient being the same in the two instances. In addition to these standard indicators of prognosis, one other was found of interest. Of the nine patients who bled in the immediate postoperative period, five died. Three required resection for bleeding, with recovery in two. The third patient was the one mentioned previously, who had many complications (Fig. 7).

Fifty-two patients had an uncomplicated convalescence. Twenty-four had one or more postoperative complications and survived. These were, in addition to the almost universal complication of adynamic ileus, pulmonary complications, either atelectasis or pneumonia, in nine; subphrenic abscess, requiring drainage, in two; thrombophlebitis, in two; pulmonary embolism, in one; wound dehiscence, in three, and pyloric obstruction, in three. Of the two patients whose perforation was closed with a *free* omental graft, both had reperforation and died. One patient with a perforated gastric ulcer and negative biopsy treated by simple closure subsequently proved to have cancer and died.

Of five patients treated by primary gastric resection, two died, or a mortality rate of 40%, one of Staphylococcus septicemia, and the other of debility, with perforation in the hospital, where she was confined with a fractured hip.

Of the total series of patients with perforated peptic ulcer, 21 died, or a mortality rate of 22%. If the seven patients in whom perforation of a peptic ulcer was first discovered at autopsy are omitted, the mortality rate was 15%. Such distressing figures are a reflection of the morbidity and mortality of old people with advanced degenerative disease, who happen to have perforation of a peptic ulcer in addition to their other disabilities, rather than being the morbidity and mortality rates of peptic ulceration with perforation alone.

Even so, perforation of a peptic ulcer continues to be a hazardous occurrence, associated with extensive morbidity and significant mortality, some of which is related to treatment.[3,7,11]

In patients less than 50 years of age, in good condition, treatment by suction and antibiotics, by simple closure, or by primary resection is usually successful, but reexamination of each of these methods of treatment is only prudent, and more sharply defined criteria should be advanced for the employment of each.

We believe that nonoperative treatment should be limited to patients who enter the hospital several days after perforation, who are well on their way to recovery, the forme fruste of yesteryear. The perforation has already sealed off, and closure by sutures is not necessary.[6] Indeed, operation

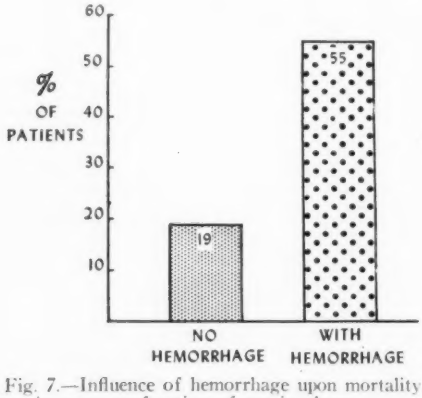

Fig. 7.—Influence of hemorrhage upon mortality rates in acute perforation of peptic ulcers.

may be harmful. Such patients are *few*.[10] All other patients, we believe, are treated best by prompt surgery, with the reservation that careful preoperative preparation is helpful in all patients and absolutely essential in patients with hypotension or significant tachycardia.[4,5,12,13]

Gastric contents produce a "burn" of the peritoneum, and enormous amounts of plasma and fluid are lost into the peritoneal cavity. This need may be concealed by hemoconcentration, but it is real, and 5000 cc. or more of blood and plasma may be required to correct this deficit. This should be done preoperatively.

Although patients in satisfactory condition, particularly the ones with early perforation, can undergo resection safely, closure of the perforation with interrupted sutures, reinforced with omentum or a bit of fatty tissue, is satisfactory, and presumably less of a strain upon the aged or debilitated patient. Closure with a *free* omental graft has not been satisfactory *at all* in our experience and is avoidable and, we believe, unwise. Sutures can always be introduced far back from the perforation and tied securely. Omentum or other fatty tissue *in continuity with its blood supply* can then be used to cover or reinforce the closure.

In patients whose ulcers perforate and bleed, the mortality associated with simple suture has been prohibitive, and resection is wise as soon as massive hemorrhage occurs, whether or not the perforation has been sutured previously. In patients with perforation of a gastric ulcer the likelihood of cancer is so great, even in the presence of negative frozen-section examination at the time of surgery, that primary gastric resection is desirable.[14] When the ulcer is in the fundus, or so near the cardia that it cannot be included in a resection, it should be excised locally in toto as a biopsy specimen, rather than a sampling of the inflamed area taken from around it.

Summary

A review of 98 patients with perforation of a peptic ulcer seen at the Milwaukee County Hospital has been made.

On the basis of this analysis, we feel that there are definite indications for the use of each of the three modalities of treatment suggested, i. e., suction and antibiotics, simple closure, and primary gastric resection.

The morbidity and mortality reported in patients with perforated peptic ulcer may be a more accurate indication of the type of patient considered and the extent of associated defects than of the disease itself, but careful preoperative support, including full restoration of blood volume, will do much to minimize both.

The wisdom of a return to fundamental principles is suggested.

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Pigeon Breast—Congenital Chondrosternal Prominence

Etiology and Surgical Treatment by Xiphosternopexy

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The three deformities of the anterior chest wall commonly referred to as funnel chest, pigeon breast, and Harrison's groove I believe [1,6-8] to be congenital and produced during infancy by abnormal, unbalanced contractions of an abnormally developed diaphragm. This etiology of pigeon breast, when first proposed in 1949,[1] was justifiably questioned because of the paucity of the evidence then submitted. I shall present further evidence to support this theory. Until recently rickets was generally accepted as the etiologic factor in this deformity, and little has been written concerning it beyond Lester's [2] proposal that it is primarily due to the abnormal overgrowth of the involved ribs. Recently, Chin,[3] in the 1956 Hunterian Lecture delivered before the Royal College of Surgeons, came to the support of my diaphragmatic theory with biopsy and autopsy studies of diaphragms, as well as the description of a very effective operative procedure based on this theory. This operation, which results in a gradual correction of the deformity to a practically normal contour, seems to refute all other etiologic theories and strongly supports my own.

The normal thorax of the newborn in humans and quadripedal animals is round, bell-shaped, and practically inert. During the period of infancy of both, the thorax becomes ovoid, but with the elongation in opposite directions in the two forms; namely, in the transverse diameter in humans and in the dorsoventral diameter in quadripedal animals. Nevertheless, I have found the diaphragm of the pig, sheep, cow, horse, and dog grossly similar to the normal diaphragm of humans. Although the thoraces of man and quadripedal animals differ, each type is constant and characteristic. This must be due to the fact that the muscular segments of the diaphragm in each type of thorax have a balanced relationship not only as to structure but also as to their contractile forces. In the one exception among animals, found in a puppy with a typical funnel chest, there was an absence of the anterior segment of the diaphragm. According to Sir Arthur Keith,[4] this difference between man and animal is due to the change in the type of posture and breathing.

> In quadripedal animals, such as the horse and dog, in which the chest rests and is supported between the forelimbs, the thorax has its greatest diameter in the dorso-ventral direction. In orthograde animals (man, anthropoids, and also in some water living animals such as seals, etc.) the transverse diameter becomes the greater—with a change in posture from the pronograde to the orthograde the action and fixation of the musculature of the body will become greatly modified; the mechanism of respiration was necessarily altered.

The conversion of the infantile, round chest into the ovoid chest of the child must be influenced by the change from the recumbent to the standing position, particularly when the infant begins to walk and increases its activity. It will be helpful to review some of the anatomic and physiologic features of the chest and diaphragm of the infant and child, since it is proposed that congenital chondrosternal prominence, or pigeon breast, begins to evolve with the

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first inspiration, although this fact is frequently overlooked.

Anatomy and Physiology

The normal diaphragm is a musculotendinous membrane divided into two hemidiaphragms, each independently innervated. Its radiating muscle bundles take their origin at the lower thoracic circumference and end in long tendinous fibers, which join and are fused together to form a central trefoil-shaped, fibrotendinous portion, comparable to the spokes of a wheel ending in the hub. Each hemidiaphragm consists of three unequal segments. The anterior segment, which is the shortest, thinnest, and therefore the weakest, arises on the posterior surface of the gladiolar-xiphoid junction and the fused sixth and seventh costal cartilages. It is inserted into the anterior leaflet of the central tendon. The lateral segment has a much stronger musculature and arises on the internal surfaces of the 7th to the 11th rib and is inserted into the outer margin of the lateral leaflet of the central tendon. The posterior segment, joined by the two crurae, arises on the anterior surface of the 12th rib and is inserted into the posterior margins of the lateral leaflets. In the infant, the domes of the diaphragm are relatively flat and occupy a high position. The costophrenic sinuses are shallow laterally and posteriorly and absent anteriorly.[5] During infancy, the diaphragm is practically the sole mechanism for drawing air into the lungs and descends only a fraction of a centimeter to draw the required amount of air for normal inspiration.[6] Any unusual inspiratory effort, such as occurs in crying or hiccuping, causes a pull on the anterior (weakest) segment and its attachment to the anterior chest wall and will produce inspiratory Harrison's grooves or a "funnel" or both. This may be demonstrated by holding the hand over an infant's nostrils and mouth. This phenomenon is particularly noticeable in the premature infant, whose anterior chest wall is softer and more yielding.

As the infant develops and begins to stand erect and walk, greater respiratory movements are required, and the thorax and diaphragm change to meet these demands. The thorax becomes longer and ovoid because the ribs, which were horizontal and semicircular, grow out laterally and downward, causing the sternum to descend. The intercostal muscles and other auxiliary muscles of respiration assume their role in chest expansion. The domes of the diaphragm are now lower and become longer and rounder, causing the costophrenic sinuses to become deeper. The contractions now can create much greater excursions to meet the greater physiologic and physical demands. In a previous publication,[6] I stated that, contrary to current belief and teaching, the diaphragm does not contract and descend in a piston-like motion; instead, the central area of the tendinous portion, which is fused with the inferior surface of the pericardium, is practically fixed. This can be observed fluoroscopically in a patient with a pneumoperitoneum. Hence, when the muscular portion of the diaphragm contracts, each dome is flattened, and a pull is exerted in the direction of its origin toward the lower circumference of the thorax. Thus, during normal respiration in normally developed infants and children, there is no retraction of the anterior chest wall because the diaphragmatic contractions are balanced, somewhat in the manner of a "tug of war."

In previous publications,[1,6-8] I described how unbalanced contractions, due to congenital weakness of the anterior segment of the diaphragm, can produce the deformities of chondrosternal depression, or funnel chest, and Harrison's grooves. It was shown how an inspiratory pull limited to the gladiolar-xiphoid junction would create a "funnel" depression, and how, if the pull was limited to the diaphragmatic attachment at the sixth costal cartilage, it would create Harrison's grooves. If an inspira-

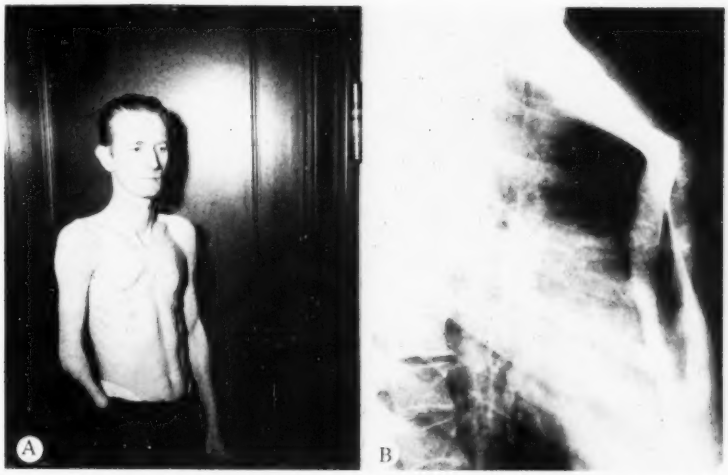

Fig. 1.—*A*, typical chondromanubrial prominence, a form of pigeon breast, or chondrosternal prominence. Note congenital absence of right hand. *B*, x-ray showing prominence of manubrium and lower adjoining ribs in normal position.

tory pull is created along the attachment of the entire anterior segment, a diffuse type of chondrosternal depression, or funnel, will result. If there is no pull on the anterior chest wall, no deformity will result. Arnheim,[9] who recently reported on the repair of absence of the hemidiaphragm in two infants, informed me that both infants had normal chests. This appears to be an example of a "balance" due to an absence of opposing forces or pull on one side of the chest and a "balance" of the contractile forces of the only hemidiaphragm. This refutes the claim that "a short central tendon" or a hypertrophied retrosternal ligament, both passive structures, is the etiologic agent. Recently, Wallis,[10] who has published an excellent study of the etiology and significance of Harrison's grooves, with the concurrence of the *British Medical Journal*, has come to the support of my theory.[6]

Congenital Chondrosternal Prominence

In the 1949 publication,[1] the abnormal diaphragm of an infant who had a typical chondrosternal prominence, or pigeon breast, was described. The inspiratory chest retractions during the life of this infant could be stopped on either side by paralyzing the hemidiaphragm after an injection of procaine into the phrenic nerve. This fact, together with the unusual diaphragm found post-mortem, led to the belief that the unbalanced contractions of that abnormal diaphragm were responsible for the production of this deformity. Three additional diaphragms accompanying this deformity have been studied through the cooperation of Dr. J. Lawrence Angel, of the Department of Anatomy of Jefferson Medical College.

Congenital chondrosternal prominence, variously referred to as pigeon breast, chicken breast, pectus carinatum, and pyriform chest, and characterized by a protrusion or prominence of the chondrosternal area, exists in two forms. The commoner form, which may be termed chondromanubrial prominence, is characterized by a protrusion of the manubrium and the adjoining first and second cartilages and a vertical or depressed gladiolus (Fig. 1). It is usually accompanied by Harrison's grooves, of varying depth. In this deformity, the protrusion ends at the point where the depression of funnel chest commonly begins. In infants with this deformity,

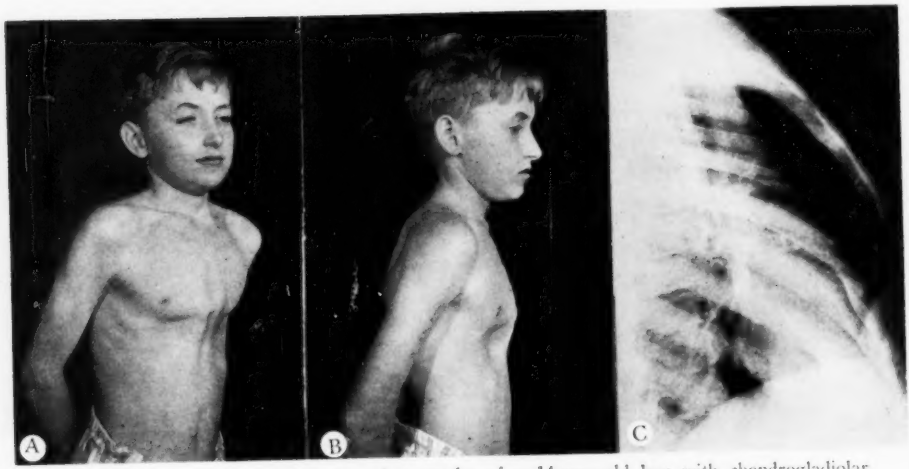

Fig. 2.—*A* and *B*, preoperative photographs of a 14-year-old boy with chondrogladiolar prominence, a form of pigeon breast, or chondrosternal prominence with deep Harrison's grooves. (Note tendency toward a quadripedal chest.) *C*, x-ray showing forward protrusion of the gladiolus, similar to that in quadripedal animals.

the upper half of the anterior chest wall protrudes forward, and in the lower half one observes a diffuse inspiratory retraction of the gladiolar area and at the anterior diaphragmatic attachment to the sixth costal cartilages. As the infant develops into childhood and the thorax elongates, the infantile rotundity of the upper thorax of the manubrial area is retained, while the lower gladiolar area appears flattened. Gradually the deformity becomes fixed and assumes a very definite pattern. In the lateral view, the anterior contour of the thorax assumes the shape of a question mark (Fig. 1). It will be noticed that the gladiolus is only relatively retracted and exerts no compression on the mediastinal contents.

Two diaphragms were available for study from cases of this chondromanubrial type of deformity.

Diaphragm 1.—This diaphragm was previously described in the case of a Mongoloid infant, 14 months of age, who died suddenly because of a congenital heart defect. The deformity consisted of a protruding upper anterior chest and a relatively retracted lower anterior chest, with distinct Harrison's grooves. The deformity, which was first noticed shortly after birth, had become progressively obvious. The lower anterior chest was retracted, and the Harrison's grooves deepened with each inspiration. The diaphragm had a V-shaped fibrotendinous portion, the apex of which extended to the gladiolar-xiphoid junction. The anterior segment was thin and fibrous, but the lateral segments consisted of very long, thick muscle bundles. The anterior segment was undoubtedly retracted during each inspiration by the stronger lateral muscular segments.

Diaphragm 2.—This specimen was obtained from a male cadaver with a typical chondromanubrial prominence and Harrison's grooves. No clinical facts were available. The fibrotendinous portion was also V-shaped. The lateral segments were very large and contained very long, thick muscle bundles, whereas the anterior segment was small, thin, and fibrous, with few muscle bundles (Fig. 4).

Thus far we can only assume that with this type of deformity we may expect to find such a diaphragm. Additional variations in the shape and size of the various segments may be found, but a study of the diaphragmatic musculature accompanying these deformities must include not only the gross appearance of the various segments but also the comparative contractile force of each segment.

The second form of congenital chondrosternal prominence may be termed chondrogladiolar prominence, or "quadripedal" chest. It most closely resembles the chest of quadripedal animals and perhaps may prove to be a manifestation of atavism.

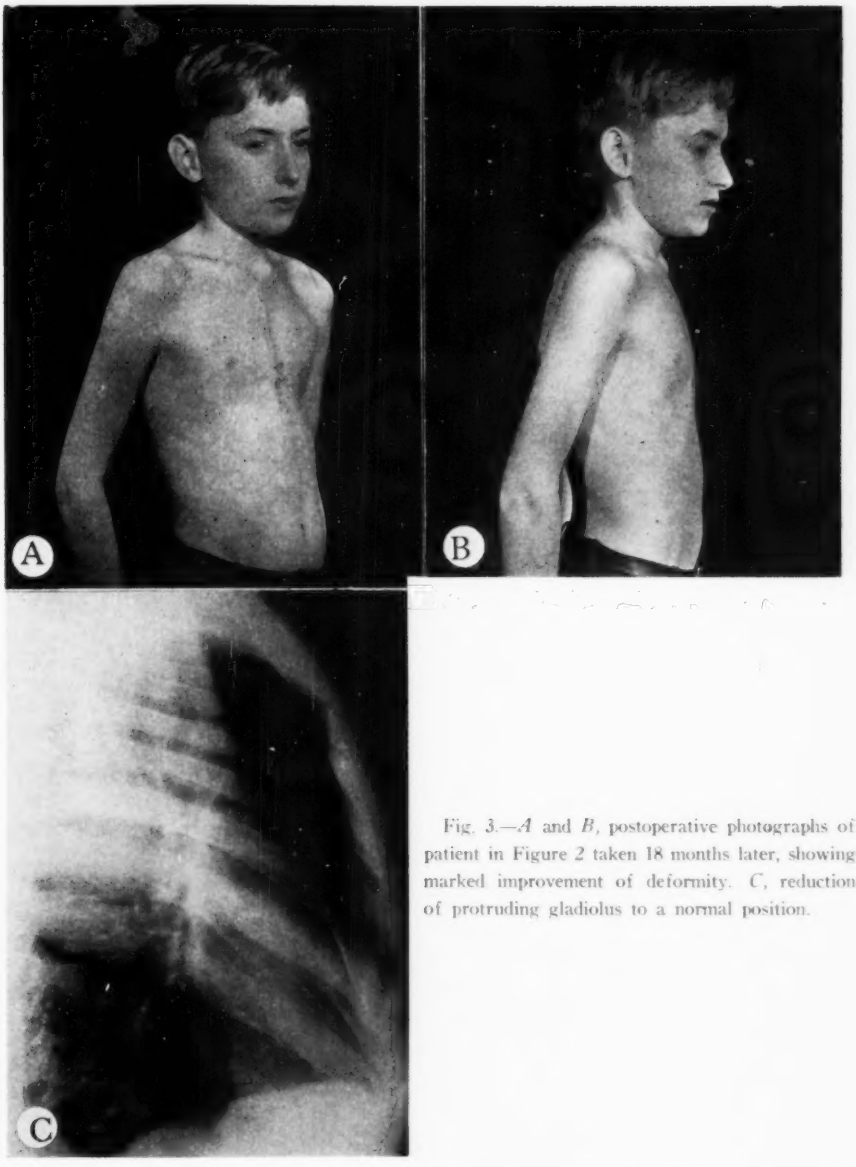

Fig. 3.—*A* and *B*, postoperative photographs of patient in Figure 2 taken 18 months later, showing marked improvement of deformity. *C*, reduction of protruding gladiolus to a normal position.

If a cross section of such a thorax is made, the thoracic circumference would be definitely pear-shaped, gradually tapering forward to the protruding sternum. The ribs and cartilages of the anterior chest below the third rib are flat and elongated. Harrison's grooves are usually present. Two diaphragms accompanying this type of deformity were available for study. In this deformity, the lower anterior thorax and the gladiolus project forward, so that the gladiolar-xiphoid junction is the most prominent part of the anterior chest wall (Fig. 2*A*, *B* and *C*).

Fig. 4.—View of abdominal surface of Diaphragm 2 in a pigeon breast of the chondromanubrial type. A strong light directed on the thoracic surface distinguishes the V-shaped fibrotendinous portion from the muscular portion. The anterior segment is small, thin, and fibrous. Note the comparatively huge lateral segment. This is almost identical with Diaphragm 1.

DIAPHRAGM 3.—This specimen was seen in a cadaver with a typical chondrogladiolar prominence, or quadripedal chest. The lower anterior ribs appeared flattened and projected forward to meet the lower protruding sternum. In this diaphragm, the thick muscle bundles of the anterior and lateral segments appeared to be a continuation of the posterior segment. There were several very long, thick columns of muscle bundles extending from the aortic and esophageal openings to the anterior chest wall. This was a most unusual diaphragm, because it did not have a central trefoil-shaped, fibrous portion or the normal delineations that mark the borders of the different segments. As the muscle bundles of the anterior and lateral segments approached their anterior attachments, they became fibrous (Fig. 5).

DIAPHRAGM 4.—This was seen in a cadaver with a typical chondrogladiolar prominence, or quadripedal chest. The fibrotendinous portion was much smaller than normal and was V-shaped. The long muscle bundles of the lateral segments extended slightly into the middle of each limb of the *V*, creating the suggestion of a trefoil shape (Fig. 6).

Fig. 5.—View of abdominal surface of Diaphragm 3 removed from a pigeon breast of the chondrogladiolar (quadripedal) type. Note the absence of the central trefoil-shaped fibrotendinous portion. The thick, broad anterior and lateral segments are much larger than normal and appear to be a continuation of the posterior segments. Note the thick muscular columns extending forward from the aortic and esophageal openings to the anterior chest attachment.

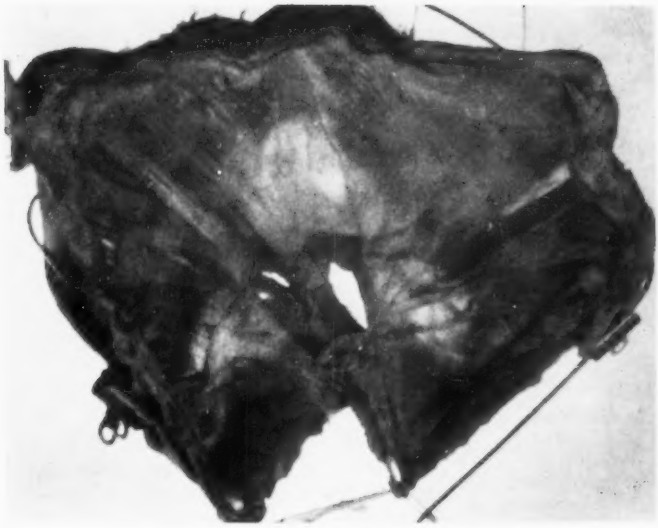

Fig. 6.—View of abdominal surface of Diaphragm 4 in a pigeon chest of the chondrogladiolar (quadripedal) type. The fibrotendinous portion was V-shaped and smaller than normal. The anterior and lateral segments were both larger than normal. Note, however, the unusual thickness and length of the muscle bundles of the lateral segments.

The lateral segments had very long, thick muscle bundles, which extended to the aortic and esophageal openings. The anterior segments also appeared longer and thicker than one sees in a normal diaphragm but were much smaller than the adjacent lateral segments. Another unusual feature of this diaphragm was the presence of three large muscular ridges in the right lateral segment, which produced deep depressions, about 2 cm. deep, on the underlying superior surface of the liver.

In both forms of congenital chondrosternal prominence, or pigeon breast, the deformity is usually symmetrical, affecting both sides of the thorax. However, each form may be unilateral, just as one may have a unilateral Harrison's groove or a unilateral chondrosternal depression, or funnel chest. These unilateral forms have been confusing because, instead of their being classified with the three deformities, where they belong, they have been regarded simply as an overgrowth of the involved ribs or a mainfestation of rickets. Furthermore, combinations of any one of these three deformities of the anterior chest wall have been observed, such as a chondromanubrial prominence with a funnel depression. This occurrence has also added to the difficulty of proper classification and diagnosis. I have surgically treated two patients with a unilateral chondromanubrial type of deformity, with very gratifying results.

Surgical Cases

(*a*) *Unilateral chondromanubrial prominence*

CASE 1.—Girl; age 14. The history is irrelevant except that the deformity was first noted at the age of 3 years. The parents were told that it was due to an unusual cartilage formation. Physical examination was negative except for multiple neurofibromatosis of the skin and the chest deformity. The latter consisted of a unilateral prominence of the first and second right cartilages and the right half of the manubrium of the sternum, which appeared as a rounded mass about 6 cm. in diameter. The girl was very self-conscious and unhappy about the deformity, and the parents were anxious to have it corrected. An x-ray of the chest was negative. Surgical excision of the two protruding cartilages and the outer portion of the manubrium gave a very satisfactory result.

(*b*) *Combined unilateral chondromanubrial prominence and chondrosternal depression (funnel chest)*

CASE 2.—Man; age 24. The chest deformity was noted at 6 months of age, during an attack of pneumonia. He had been told it was due to rickets. The deformity was of a combined type, namely, a chondrosternal depression, or funnel chest, and a right unilateral chondromanubrial prominence. The "funnel" was 14 cm. long and

14 cm. wide, with a depth of 3 cm. The anteroposterior diameter of the chest at the gladiolar-xiphoid junction was 16 cm. and that at the mammary line 19 cm. The unilateral prominence consisted of the protruding right first and second cartilages and right half of the manubrium. His physical endurance was limited. An excellent result was obtained by resecting the protruding deformity of the upper right chest and correcting the chondrosternal depression or funnel chest by a chondrosternoplasty. Wire traction, to maintain the elevated sternum, was utilized for 10 days. The result was very satisfactory not only cosmetically but because of the relief of symptoms of mediastinal pressure.

(c) Chondrogladiolar prominence (quadripedal chest)

CASE 3.—Youth; age 14 years; height 68 in. The parents noticed a "lump" on the lower anterior chest during early childhood and stated that it had gradually been becoming more prominent in the last few years. Following a normal delivery, he had been breast-fed the first few months. The parents and two older children had normal chests. The medical history was negative. The boy was very concerned about the deformity and was adamant about having it corrected. Physical examination of this well-developed boy was negative except for a quadripedal chest deformity, which started at the level of the third rib, with progressive protrusion forward to the gladiolar-xiphoid junction. Both pectoralis major muscles originated 2 in. lateral to the sternum, and both rectus muscles were widely separated and extended up to the costal arch. Surgery consisted of resection of the protruding segments of the fourth to the seventh cartilages, beginning at the lateral borders of the prominence. A horizontal incision was made in the sternum at the level of the third interspace. The xiphoid process and the attached rectus muscles were mobilized. After the underlying soft structures were separated from the sternum, the latter could easily be bent into a normal position and maintained by a narrow wedge of rib placed into the widened horizontal incision of the sternum. The stumps and ends of the ribs were shaped and aligned and then sutured with wire so that a normal contour of the anterior chest was obtained. The mobilized muscles were sutured on the chest wall in their more normal position. The cosmetic result was very satisfactory.

I received a communication from Chin [11] which described his procedure for the correction of this type of deformity, and I applied it to two patients, aged 6 years and 20 months, respectively, both of whom had a chondrogladiolar prominence, or quadripedal chest. Chin's procedure is particularly suited for young children and infants, when the thorax is soft and yielding. It was applied to these two patients, with very satisfactory results (Fig. 7*A* and *B*).

(d) Chondrogladiolar prominence and Harrison's grooves

CASE 4.—Boy; age 6 years; frail appearance; weight 48 lb.; height 47 in. The medical history

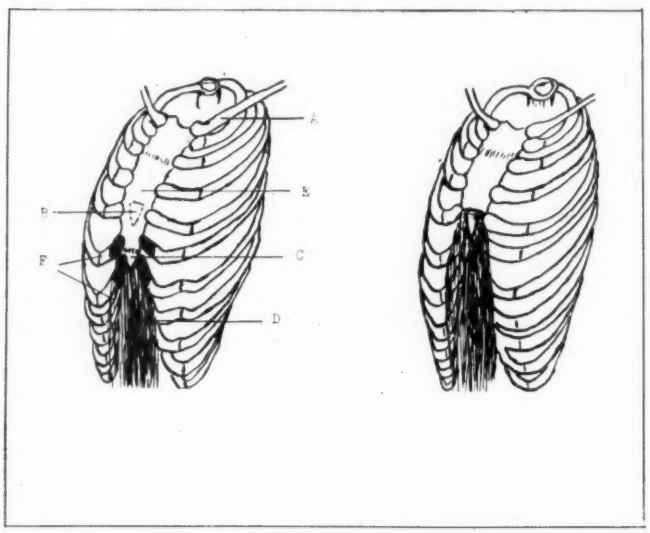

Fig. 7.—Surgical treatment (xiphosternopexy) of congenital chondrosternal prominence (pigeon breast).

Principle of operation: Xiphoid process with attached rectus muscles is mobilized and sutured into a notch made as high on the sternum as possible. Small segments of the fifth and seventh cartilages near sternum are resected. (*A*) clavicle; (*B*) notch in sternum; (*C*) xiphoid process; (*D*) rectus muscles; (*E*) protruding sternum; (*F*) resected segments of fifth to seventh cartilages.

was negative. When he was an infant, the parents were told that the chest was abnormal because of rickets but that he would outgrow it. Physical examination disclosed a large congenital heart with a probable septal defect. Although the parents were advised to have the child's cardiac condition evaluated for possible surgical treatment, they were interested only in correcting the chest deformity, which was a chondrogladiolar prominence, or quadripedal chest, with marked anterior bowing of the gladiolus and flattening of the lower anterior ribs, with deep Harrison's grooves. The pectoralis major and rectus muscles were all 1 in. lateral to their normal positions. The operative procedure followed Chin's suggestion. A vertical midline incision was made over the sternal prominence. The xiphoid process and the attached rectus muscles were separated from the costal arch and sutured with wire sutures into a groove made as high up on the sternum as possible. This was at the level of the fifth cartilage. Small segments of the fifth to the seventh costal cartilages were removed near the sternum to permit the sternum to descend. The separated pectoralis and rectus muscles were sutured to the sternum with fine chromic absorbable surgical sutures. The operation was performed in May, 1956, and in December, 1957, examination showed there had been considerable improvement in the deformity. The deep Harrison's grooves were scarcely visible, and the right side of the thorax had a normal contour. The left anterior thorax, although it had regressed considerably, is more prominent than the right, undoubtedly owing to the hypertrophied heart directly underneath.

CASE 5.—Boy, aged 20 months; a robust, well-developed infant. The deformity was not noticed during the first year, probably because of obesity. He had pneumonia at the age of 9 months. The family history was negative. There were deep Harrison's grooves and a distinct anterior bowing of the sternum, with marked flattening and depression of the lower cartilages. The parents were concerned about the deformity and were told that surgical treatment would bring about a gradual correction. Surgery was performed in September, 1956, and consisted of freeing the xiphoid process with the attached rectus muscles and suturing it with wire sutures as high up as possible into a notch made in the gladiolus (Fig. 7). Small segments of the lower two cartilages were resected near the sternum. In December, 1957, the deformity was greatly reduced.

The indications for surgery in patients with chondrosternal prominence, or pigeon breast, are more limited than those for depression deformities because of the absence of symptoms due to pressure on the mediastinal structures. The chief indication for surgical treatment is cosmetic. Surgery for this purpose is too involved to correct a fully developed pigeon breast of the chondromanubrial variety except the unilateral form, as in Cases 1 and 2. Surgical correction by a chondrosternoplasty is warranted in a person with a chondrogladiolar, or quadripedal, form of pigeon breast, because a good cosmetic result can be obtained with comparative ease, as in Case 3. In unilateral types, the deformity appears more distinct and prominent and often concerns the patient sufficiently to warrant surgical correction. This can be satisfactorily accomplished by a limited chondrosternoplasty. Surgery is definitely indicated in children with chondrosternal prominence because they still have a soft, yielding anterior chest wall, and a gratifying result can be anticipated with a comparatively simple procedure, such as xiphosternopexy (Fig. 7*A* and *B*) has proved to be. Although Chin's and my cases do not constitute a large series, the operation so far appears to be the best and only procedure that can gradually correct this condition.

Chin[3] states that his procedure of detaching the xiphoid, with its anterior diaphragmatic and rectus attachments, and suturing it high on the anterior surface of the lower sternum is designed "to restore the anatomy to normal." This then brings support to the lower sternum and prevents its forward displacement during inspiration. This maneuver undoubtedly shortens and narrows the fibrous anterior segments and brings the lateral segments more medially. In any case, more balanced diaphragmatic contractions appear to result. In addition, the rectus muscles in the higher position exert a greater downward pull on the elevated sternum. Gradually these altered forces restore the sternum to a more normal position, with diminution of the lateral depressions or Harrison's grooves. Therefore, the parents of a prospective patient must be told that they are

not to expect a dramatic change immediately after the operation, but that within two years they can expect to see a fairly normal chest as the infant grows and develops. Obviously, one can expect the best results if surgery is performed when the child is young and the chest is more yielding. As the thorax becomes progressively more rigid, it is more difficult for this procedure to effect a change. Therefore, the ideal time for correction appears to be during infancy and childhood.

Summary

The so-called pigeon breast deformity, characterized by prominence of the chondrosternal area, occurs in two forms. In the first, the chondromanubrial, the prominence consists of the manubrium and its adjoining first and second cartilages. The second form, the chondrogladiolar prominence, or quadripedal chest, is characterized by a protrusion of the gladiolus and its adjoining cartilages. Although the deformity is usually symmetrical, it may be unilateral or combined with Harrison's grooves or funnel chest. Further evidence has been presented to support the theory that the pigeon breast, or congenital chondrosternal prominence, is produced by a pull on the anterior chest wall attachment resulting from unbalanced diaphragmatic contractions of an abnormally developed diaphragm. This abnormal diaphragm is usually characterized either by a comparatively stronger musculature of the lateral segments or by a weak, underdeveloped musculature of the anterior segments. Furthermore, it appears that following Chin's surgical procedure there is a gradual and progressive reduction of the deformity. The chest assumes a normal contour because the abnormal pull on the anterior chest wall has been neutralized and the radiating forces of the diaphragmatic contractions have been brought into balance. Four abnormal diaphragms accompanying the two forms of pigeon breast are described. The surgical treatment for the correction of this deformity is discussed. Surgery is not indicated in adults who have fully developed pigeon breast deformities except in the case of a severe chondrogladiolar type. The unilateral types are sufficiently disfiguring to warrant surgical correction which provides a good cosmetic result. An operative procedure, first suggested by Chin, in England, and successfully applied by him and myself, is described. This operation of xiphosternopexy is definitely indicated in young children with pigeon breast deformities, because one can expect a practically normal chest result within two years. This result appears to be produced by a restoration of balanced diaphragmatic contractions and thus supports the diaphragmatic theory of the etiology and pathogenesis of this condition.

Mr. E. F. Chin furnished the photographs and Figures 2 and 3, and Roger H. Brodkin, the drawings in Figure 7.

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Neurofibrosarcomas of Cranial Nerve Origin

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Neurofibrosarcomas of the head and neck are uncommon. The difficulties encountered in their proper care are of such complexity that an appraisal of their clinical course and surgical management is indicated.

Since they were first described, there has been little unanimity of opinion regarding the cell origin of these tumors, and accordingly they have been called by a variety of names. Some authors[1-3] have stressed their Schwannian origin and thus call them malignant schwannomas. They have also been designated by the synonyms of neurogenic sarcoma,[4,5] neurosarcoma,[6] and neurofibrosarcoma.[7] We prefer the last term because it is well established and easily understood and because it describes the histological appearance without entering into the controversy of its cellular derivation.

The clinical appearance of neurofibrosarcomas is not diagnostic. In the area under discussion they are usually of small or medium size, resilient, smooth, and occasionally painful. Ulceration occurs only late in their course. Anatomic form varies from a subcutaneous nodule to diffuse involvement of an identifiable nerve. At the same time, the clinical behavior of these tumors is erratic and deceptive. Ewing,[4] Stewart and Copeland,[5] and others have emphasized the characteristic of multicentric origin of new tumors along the same nerve, which simulate metastases. In addition, neurofibrosarcomas may begin as small subcutaneous nodularities, which, although initially having an innocent appearance, persist in their tendency to local recurrence, with eventual fatal termination.

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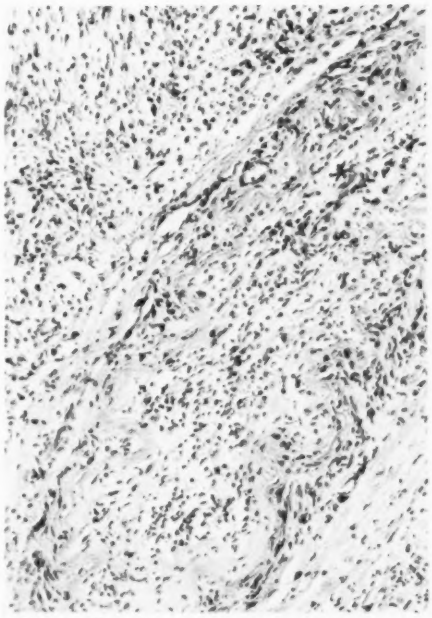


Fig. 1 (Case 1).—Photomicrograph demonstrating venous embolism, which is the usual method of metastasis of neurofibrosarcomas. As yet there is no evidence of disseminated tumor in this patient.

Better-understood characteristics are the more favorable postoperative prognosis when the tumor is pseudoencapsulated[4] and the direct relationship between postoperative longevity and histologic gradation of the tumor.[8] These tumors have a propensity for venous spread (Fig. 1) with pulmonary metastases, the incidence in the series of Vieta being as high as 45% in the determinate group. Although some authors[9] have demonstrated their frequent relationship to von Recklinghausen's disease (Fig. 8), this association has been present in only two instances in this relatively small series. As a group, these tumors are very radioresistant, so that irradiation does not enter into consideration

in their therapy. All the above characteristics make the neurofibrosarcomas a problem of great difficulty, and their surgical management in the head and neck region requires thinking somewhat different than that for other malignancies in this area which have better-known growth characteristics and more predictable metastatic patterns. These considerations lead to the necessity, in the following series, for a versatility in surgical approaches for a group of tumors which initially appeared to have an essentially similar clinical appearance and malignant potential. The salient features of the case histories of the patients in this series are presented and will serve as the basis for the discussion which follows.

Report of Cases

CASE 1.—A 56-year-old man. The patient stated that as a child he had injured his lower lip and that ever since a lump had been present at the site of injury. In 1949 the nodule began to increase in size and finally became ulcerated. In December, 1950, the nodule was excised locally by his physician; although it was reported to the patient as being benign, no microscopic sections of the lesion were available. A month later the wound became ulcerated and remained so until we first examined him, in August, 1951.

Physical examination revealed a resilient, slightly painful mass, 2 cm. in diameter, in the midportion of the lower lip. The remainder of the physical examination and all laboratory tests were normal. Under general anesthesia, a biopsy specimen was obtained, and a frozen section was reported as "granuloma." Accordingly, a wedge resection of the lesion was performed. Examination of the paraffin sections showed this to be a neurofibrosarcoma. The patient was again brought to the operating room, the previous operative site widely excised, and an Äbbe flap used for plastic repair. Surprisingly, numerous sections of this tissue did not reveal residual tumor.

Eighteen months later, in February, 1953, a tiny nodule was noted on the mucosal surface of the left lower lip at the level of the commissure. The tumor was excised under local anesthesia; but when microscopic sections showed it to be recurrent tumor, the operative site was widely excised under general anesthesia, and microscopic sections of this specimen showed adequate margins of normal tissue. Five months later the patient again presented himself with a subcutaneous coin-

Fig. 2 (Case 1).—Operative photograph. The fourth subcutaneous recurrence was traced down to the mental foramen, and, by removing the outer portion of the mandible, the involved inferior alveolar nerve (*N*) was exposed. The mandible was fractured at the mandibular foramen and the nerve dissected to near the foramen ovale, where it was sectioned and found to be grossly normal. Because of dental nerve involvement, as seen microscopically (Fig. 3), a left partial mandibulectomy was subsequently performed.

shaped lesion over the left mental foramen. At surgery, an incision was made to encompass the tumor, and, as the dissection progressed, the mass was found to involve the inferior alveolar nerve as it emerged from the mental foramen. With the use of bone rongeurs, the outer portion of the mandible back to the mandibular foramen was removed, thereby exposing the inferior alveolar nerve in its entirety. It was found to be uniformly enlarged (Fig. 2) and reddish-blue in color. For adequate exposure and further dissection the mandible was fractured at the mandibular foramen and the nerve followed proximally to the foramen ovale, where it was sectioned and grossly appeared normal. Paraffin sections of the tumor (Fig. 3) demonstrated tumor along an adjoining nerve, which was assumed to be a dental nerve. Since such an interpretation meant incomplete excision, further surgery, a week later, consisted of excision of the mandible from the symphysis menti to just proximal to the mandibular foramen. The patient's convalescence was uneventful, and to date there has been no evidence of recurrent tumor.

CASE 2.—A 45-year-old woman. In May, 1947, the patient noticed a "pimple" high on her midforehead, which was excised locally by her physician. No microscopic section or diagnosis of

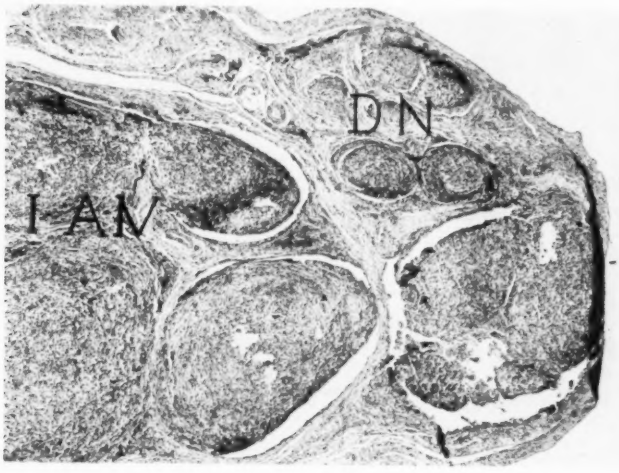


Fig. 3 (Case 1).—Low-power photomicrograph of the inferior alveolar nerve (*IAN*). The branches labeled (*DN*) were presumed to be dental nerves and show evidence of tumor invasion. This patient was subjected to a left partial mandibulectomy.

the excised tumor is available. In 1949, the tumor recurred in a slightly lower location and was locally excised. Again, no diagnostic data are available. Two years later, in May, 1951, it recurred just over the bridge of the nose. This was excised locally, and the microscopic diagnosis was neurofibrosarcoma. In April, 1952, the patient entered the Research and Educational Hospitals of the University of Illinois with a recurrent tumor just over the left supraorbital foramen. A local excision with primary closure was done, but the microscopic sections showed an inadequately excised neurofibrosarcoma. The skin over this area was widely reexcised and the defect covered with a split-thickness skin graft. Microscopic sections again showed sporadic areas of incomplete excision both at the margins and in the depth of the wound, so that a radical procedure was planned. In January, 1953, full-thickness skin of the entire forehead, along with the outer table of the frontal bone within this area, was excised and the defect covered temporarily with a split-thickness skin graft. In subsequent operations a tube pedicle was migrated from the abdomen and grafted to the forehead, with an excellent cosmetic result. There has subsequently been no evidence of recurrence.

Case 3.—A 17-year-old girl. In December, 1948, the patient first noticed a "pea-sized" growth behind the right ear. It was excised by her family physician, and the microscopic diagnosis was low-grade neurofibrosarcoma. The lesion recurred soon postoperatively, and five months later, in June, 1949, she presented herself for examination. The pertinent findings on physical examination were a firm, painless mass 3 cm. in diameter, with normal overlying skin, but with moderate fixation to the underlying bone in the right postauricular area. In June, 1949, under endotracheal anesthesia, a longitudinal postauricular incision behind the tumor mass was carried down to the temporal bone. The dissection to include tumor was extended anteriorly to the external auditory canal, and the posterior portion of the helix plus all of the concha and the antihelix was removed. The postoperative convalescence was satisfactory. It is now nine years since surgery, without evidence of recurrent disease. The diagnosis was residual low-grade neurofibrosarcoma.

Case 4.—A 43-year-old woman. In 1949, the patient requested medical care because of a painless, freely movable mass 2.5 cm. in diameter and situated in the right postauricular area. It had begun as a small nodule two months previously. The remainder of the physical examination was noncontributory. Regional field block was performed, and the mass was excised beyond the limits of gross tumor. The wound was closed primarily. The microscopic diagnosis was low-grade neurofibrosarcoma. The patient came under our care one and one-half years later. In the absence of any clinically demonstrable tumor, no further treatment was considered indicated. She is still without evidence of recurrent tumor, nine years after her original surgery.

Case 5.—A 59-year-old man. The patient had had dryness and scaliness of his lips for many years. In 1946, an ulcerated growth on his upper lip 1 cm. in diameter was treated with 1200 r of x-radiation; however, no microscopic diagnosis prior to therapy is available. In 1951, he cut his upper lip with a piece of glass just to the right of the previously treated area, and a noticeable scar remained. In December, 1953, he presented himself with an 8×10 mm., slightly raised, solid tumor of the right upper lip in line with the scar of the previous laceration but not associated with

Fig. 4 (Case 5).—The resilient, painless, smooth nodule of the upper lip appeared in an obvious scar from a laceration three years previously. A wide excision with primary closure was performed. The diagnosis was anaplastic neurofibrosarcoma (Fig. 5).

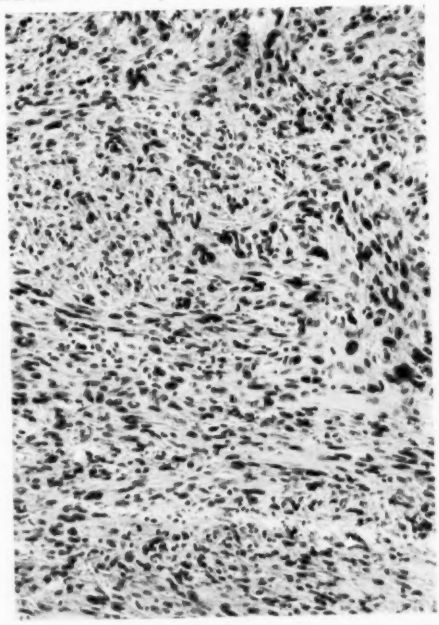
the area previously treated with x-radiation (Fig. 4). Except for moderate scaliness of both lips, the remainder of the physical examination and all laboratory tests were within normal limits. In January, 1954, a wedge excision of the tumor with a primary closure was performed. The postoperative course was without incident, and the cosmetic result was satisfactory. The pathologic diagnosis was neurofibrosarcoma with adequate margins of normal tissue. In April, 1955, a diagnosis of adenocarcinoma of the prostate was established. The patient died of the latter disease in April, 1956. There was no evidence of recurrence of his neurofibrosarcoma.

Case 6.—A 14-year-old youth. At 11 years of age, the patient first noticed a pea-sized, firm mass on the left side of the nose. This was excised, and the surgical site was treated postoperatively with external x-radiation of an undetermined amount. Six months later the tumor recurred at the same site and was treated in a similar manner. It did not recur until two years later, at which time excision and x-irradiation were again the method of treatment. In all the above instances the postoperative x-radiation was given as a matter of policy and not because of known residual disease.

When the patient was first examined by us five months later, in March, 1950, a 0.5 cm. nodule was present in the left upper lip with a similar mass in the same plane in the gingiva. A wedge resection of the involved lip and left ala was performed, with the microscopic diagnosis of neurofibrosarcoma (Fig. 5); the margins of excision were adequate. Nevertheless, eight months later there was a recurrence at the surgical site, which was excised even more widely. When he was hospitalized five months later for his fifth recurrence, the entire left maxillary area was bulging from the underlying tumor. The area was exposed through a left Weber-Fergusson incision. Gross tumor was found to involve the left orbit, but permission for exenteration was not obtainable, so that the tumor was incompletely excised. Subsequent procedures were of a palliative nature. During the next seven months, three separate recurrences at the periphery of the above surgical limits were excised. In November, 1951, both external carotid arteries were catheterized and periodically infused with sterile mechlorethamine hydrochloride N. F. (nitrogen mustard) and colchicine, with transient moderate regression of the tumor. The patient finally died, without distant spread of tumor, in July, 1952, five years after the onset of the first signs of tumor. At necropsy tumor was found to extend into the left retrobulbar area and into the middle cerebral fossa.

Case 7.—A 20-year-old white man. Three years previously the patient noticed a small tumor of the left buccal mucosa, which gradually enlarged and was occasionally tender. When the tumor was 3 cm. in diameter, he consulted his local physician, who performed a transoral biopsy and established the diagnosis of neurofibrosarcoma. When he was first examined, in July, 1955, the tumor was firm, irregular, and lying submucosally just posterior to Stensen's duct. Under endotracheal anesthesia and through an intraoral approach, a wide en bloc

Fig. 5 (Case 5).—Photomicrograph of a tumor presenting as a small subcutaneous nodule (Fig. 4). What clinically appeared to be an incisional neuroma is an anaplastic neurofibrosarcoma.



excision of the tumor was performed, and Stensen's duct was transplanted. It was necessary to sacrifice the maxillary division of the facial nerve; however, at no time was an association between tumor and a specific nerve observed. The wound was left open and packed with petrolatum U. S. P. (Vaseline) gauze. There was an uneventful secondary healing of the wound, and at present the patient is free of tumor.

CASE 8.—A 50-year-old man. The patient first noticed a nontender nodule just beneath the buccal mucosa near the right commissure of his mouth. The lesion had been present for approximately five to six months. It had increased only slightly in size since he first noticed it. Examination revealed a rubbery, firm nodule, measuring approximately 1 cm. in greatest diameter. The buccal mucosa was freely movable over it. The patient was admitted to the hospital, and in April, 1956, a local excision of the lesion was performed. Microscopically the material was consistent with a low-grade neurofibrosarcoma, which was well differentiated. The patient has been without evidence of recurrent disease to the present time.

CASE 9.—A 34-year-old woman. Eight months previously, the patient noticed a swelling of the right submaxillary triangle, associated with intermittent aching of the lower molars and of the ear on the right side. Two months later she experienced difficulty with eating because of a sensation of thickness of the tongue. Because the mass began enlarging rapidly, in April, 1954, she sought medical advice.

Physical examination revealed that the right submaxillary triangle was occupied by a rubbery, painless nondiscrete mass, which also caused the floor of the mouth to bulge inwardly. There was paresis of the hypoglossal nerve. The clinical diagnosis was malignant tumor of the submaxillary gland with invasion of the hypoglossal nerve. The surgical exploration was performed through a submandibular incision, and grossly normal submaxillary salivary gland was identified and found to be displaced by the tumor, which lay beneath it. Further dissection disclosed that the tumor arose from the hypoglossal nerve (Fig. 6). The digastric muscle was divided for better exposure of both ends of the nerve. Proximally, the nerve was sectioned 1 cm. from the hypoglossal canal at a point appearing grossly normal. Distally, a portion of the tongue was included, with the decussating nerve. The nerve along with the contents of the submaxillary triangle was excised en bloc. The microscopic diagnosis was neurofibrosarcoma with normal nerve at the extremes of nerve excision. The postoperative convalescence was uneventful. She was examined at intervals and remained free of disease until 20 months later, in December, 1955.

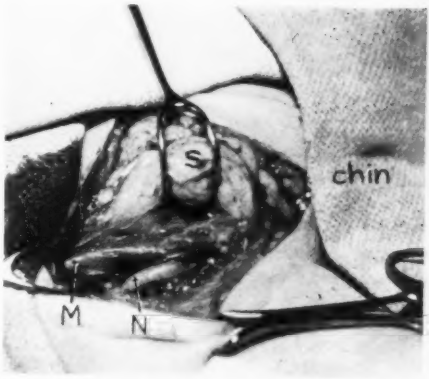


Fig. 6 (Case 9).—Operative findings in a patient with the complaint of left hypoglossal nerve paralysis. Upon retraction of the submaxillary gland (*S*), the hypoglossal nerve (*N*) was found below the posterior belly of the digastric muscle (*M*). There can be seen the beginning of a fusiform enlargement of the involved nerve as it progressed anteriorly. The contents of the submaxillary triangle were excised en bloc, and the nerve was found uninvolved at its extreme ends of resection.

There appeared within the period of a month a 1 cm., tender, deeply situated nodule at the middle of the surgical scar. Under nasotracheal anesthesia, the previous scar and a wide block of tissue around it was excised down to the pharyngeal mucosa. In the center of the excised tissue was a nodule of recurrent neurofibrosarcoma. The patient has been clinically free of recurrent disease for over two years.

CASE 10.—A 46-year-old white woman. In 1937, the patient had a large "cyst" excised from behind the left ear, but the gross and microscopic descriptions are not available. In 1941, a "fibroid" tumor was excised from the left side of the neck, but again microscopic slides were not obtained. About 1949, she began to notice a nodular swelling of the left side of the neck, which by 1951 was the size of an "egg." There was little external deformity, and the patient's main difficulty was inability to breathe when lying on her left side. In February, 1951, she was operated upon, and the above-described mass was excised, but the surgeon was not certain whether the tumor arose within the 10th or the 12th cranial nerve. The pathologic diagnosis was neurofibrosarcoma. Postoperatively she was hoarse, and she could not maintain her nutrition because of difficulty in swallowing food, some of which was promptly regurgitated through the nose. Her inability to eat was so severe that within three months she had lost approximately 40 lb. in weight. She was first seen in May, 1951, and at this time there was no function of the vagus

and hypoglossal nerves on the left side. Because of the patient's course, further surgery was planned. It was reasoned that with both cranial nerves functionless, one represented extirpation with the tumor and the other probably involvement by fibrous tissue in the operative site or inadvertent sectioning at the time of surgery. In either situation, an attempt could be made at neurolysis or neurorrhaphy, with the purpose of improving the patient's deglutition.

Under endotracheal anesthesia, the previous operative site was explored, and the hypoglossal nerve was found to be absent. The vagus nerve was involved in dense fibrous tissue just below the nodose ganglion. The vagus nerve was freed with some difficulty, and a wide reexcision of tissue in the operative site was performed, with no microscopic evidence of tumor in the excised tissue. Surprisingly, the patient's phonation and swallowing were remarkably improved, even though the left vocal cord remained paretic. She continued in a satisfactory fashion and regained her weight. Five months later she began to be troubled occasionally with morning nausea and vomiting and with unexpected nasal regurgitation of gastric contents when she leaned over. She improved with symptomatic treatment, and when she was next seen, in August, 1954, these symptoms were not incapacitating. At this time she complained bitterly of several exquisitely tender nodules in the operative site, which clinically appeared to be neuromas. These nodules were excised and the upper neck explored, the only positive findings being the amputation neuromas of the cervical plexus. Since operation, the patient has had no difficulty with swallowing or nasal regurgitation, and her phonation improved sufficiently that she resumed her position as a telephone switchboard operator. She has been without evidence of tumor for almost seven years.

Case 11.—A 6-year-old boy. The parents of the patient stated that after a fall and injury to the left jaw, three months previously, a swelling appeared in this area. Several weeks after the onset of the swelling he was taken to a dental clinic, where a molar tooth was extracted, with no regression in size of the submandibular mass. A month after the accident the family physician performed a biopsy of this mass, and the microscopic diagnosis was "chronic inflammation." The mass continued to enlarge until he was first seen, in August, 1954.

Physical examination revealed an obvious left submandibular swelling (Fig. 7*A*), which was moderately firm, painless, and fixed to the left mandible. There was mild bulging of the floor of the mouth, and the tumor extended slightly to the right of the midline. All the cranial nerves functioned normally. Stereoscopic x-rays of the left hemimandible showed bone destruction along the inferior margin, presumably secondary to invasion by a malignant process. The remainder of the

Fig. 7 (Case 11).—Preoperative (*A*) and postoperative (*B*) photographs of a patient with a neurofibrosarcoma of the left submaxillary triangle. An en bloc excision of the left hemimandible, contents of the submaxillary triangle, and the left floor of the mouth was performed. The functional and cosmetic results have been satisfactory.

physical examination and all other tests were normal. In September, 1954, surgery was performed through a submandibular incision, and full-thickness skin flaps were mobilized, with preservation of the platysma muscle and the mandibular branch of the facial nerve. Biopsy of the tumor was performed, and a frozen section revealed a malignant spindle-cell tumor. The mandible was disarticulated and also divided at the symphysis menti, and an en bloc excision of the contents of the submaxillary triangle performed. The postoperative convalescence was satisfactory. Since surgery the patient's phonation and chewing ability have been adequate. He is in the process of having a dental prosthesis constructed for better facial symmetry (Fig. 7*B*). The final diagnosis was low-grade neurofibrosarcoma. There has been no recurrent disease.

CASE 12.—A 53-year-old white woman. For the previous three years the patient had noticed that her left eye was assuming a progressively higher position within the orbit. There was no diplopia, but the occasional frontal headaches prompted her to seek medical aid. On physical examination the pertinent findings were a firm, somewhat irregular mass occupying the entire left maxillary area and causing it to bulge forward. The mass could be palpated as it extended through the infra-orbital plate. Under local anesthesia and through a transverse infraorbital incision a biopsy of the presenting tumor was performed. The microscopic diagnosis was neurofibrosarcoma. In July, 1953, the involved area was exposed through a left Weber-Fergusson incision. The hard palate, maxilla, zygoma, and contents of the orbit on the left side were excised en bloc. The postoperative convalescence was uneventful, and to date the patient has been free of disease.

CASE 13.—A 23-year-old white woman. Stigmata of Recklinghausen's neurofibromatosis first appeared in this patient at the age of 5 years. A rapidly enlarging and painful mass over the right parotid gland was excised at the age of 7 years; and since that time 15 procedures, ranging from excision of a single nodule to a radical neck dissection, have been performed in the neck and head area. All of the surgery was performed for masses which enlarged rapidly, were painful, interfered with swallowing or breathing, or were very disfiguring. Interestingly, during a recent pregnancy there was an explosive enlargement with severe pain of one of the neck tumors, which on removal was found to be a neurofibrosarcoma. On two other previous occasions excision of the tumors of separate nerves revealed neurofibrosarcoma. The patient now has a neurogenic liquid dysphagia and is sustained primarily by feedings through a nasogastric tube. Numerous large masses are located intra-abdominally, intrathoracically, and in the head and neck, so that further surgery is impractical and unreasonable.

CASE 14.—A 27-year-old white man. Fifteen years previously the patient developed a clinically obvious picture of generalized neurofibromatosis. In 1949 his left eye began to assume a progressively higher position within the orbit; however, no diplopia was present. In July, 1954, under general anesthesia, the orbit was explored and a biopsy specimen taken of an encapsulated tumor, which was seen to fill the inferior and temporal side of the orbit and to encompass the optic nerve. The diagnosis was neurofibrosarcoma, and an orbital exenteration was performed. The following month he was sent to another hospital, where plastic surgery was begun to reconstruct the left orbit. Immediately after this surgery, three nodules appeared adjacent to the operative site. These were periodically observed by his physician; and when the patient was first seen, six months later, they had attained the size shown in Figure 8. They were painless and resilient and did not appear to

Fig. 8 (Case 14).—A left orbital exenteration has been performed for a neurofibrosarcoma in the periorbital area. There was a subsequent attempt to reconstruct an orbit. The recurrence appeared soon thereafter, and, when first examined, the patient had the appearance seen in the photograph. Because tumor involved bone diffusely, a curative operation was not possible, and the patient died several months later, of his disease.

be attached to the underlying bone. X-rays of the skull and chest were normal. In April, 1955, under endotracheal anesthesia, an attempt was made to excise the lesions, but tumor was found involving diffusely the outer table of the skull, making curative surgery impossible. As anticipated, postoperative x-ray therapy to the tumor had no significant effect, and the patient died of his disease in August, 1955.

Comment

In order to correlate the material presented, a study was undertaken endeavoring to establish criteria whereby the clinical course of a specific lesion could be anticipated. Microscopic gradation of the tumor was found to have distinct, but not categorical, significance with respect to prognosis. In this regard the recurrent tumors presented the greatest difficulty in evaluation. Although not entirely true here, changes in the direction of increased malignancy with multiple excisions are not uncommon. In the series of Vieta and Pack, an increased mortality was correlated specifically to such an increase in malignancy of the recurrent tumors. The longest survivals in our series were of patients with relatively well-differentiated tumors, albeit numerous recurrences took place in this group even with microscopically adequate excisions. Of the patients whose tumors demonstrated an anaplastic histologic pattern, one died of his disease, and the others have been operated upon too recently to be of statistical significance. However, it is our impression that the degree of tumor anaplasia has a clear relationship to the surgical curability of the tumor.

In attempting to assess the significance of a pseudocapsule, it appears that such a characteristic carries with it a more favorable prognosis, an observation noted also by Ewing. The tumors in the two oldest cases in this series had this architecture. However, it is also true that in several cases in which the tumors not only were clearly enveloped by a pseudocapsule but also were histologically well differentiated, there followed a course of multiple recurrences before the tumors were brought under apparent control. None of the tumors with a pseudocapsule were considered to be very anaplastic, and several of the well-differentiated tumors possessed no such architecture. In this respect we believe that the tumors with a pseudocapsule had a better postoperative prognosis as much for this gross feature as for the frequently associated low-grade malignancy.

Of the 14 patients in this report, 8 presented themselves with subcutaneous nodules; 4 had tumors arising within deeper structures of the head and neck, and 2 had an associated neurofibromatosis. In the eight patients whose initial complaint was a subcutaneous nodule, 26 surgical procedures were performed in attempts to control the lesions; this includes one patient operated upon too recently for recurrence to appear. This would appear to demonstrate the futility of wide local excision of subcutaneous neurofibrosarcomas. However, such an impression may be more apparent than real, and actually is an expression not only of the natural behavior of these tumors, but also of the practical surgical limitations imposed by the vital structures involved.

In an attempt to find a reason for multiple local recurrences, a first impression might be the possibility that the tumors had a microscopic filamentous extension proximally along the involved nerve. Since most of these tumors appear as discrete nodularities without a suggestion of involvement of a specific nerve filament, in the usual wide excision such a microscopic sliver of tumor might easily remain and obviously promptly recur. However, repeated examination of the gross specimens and of the microscopic slides revealed no instances of inadequate excision of any specific tumors where this situation was not detected and corrected. We have come to agree with Ewing and Stewart and Copeland, who believe that in such instances of multiple recurrence in areas ob-

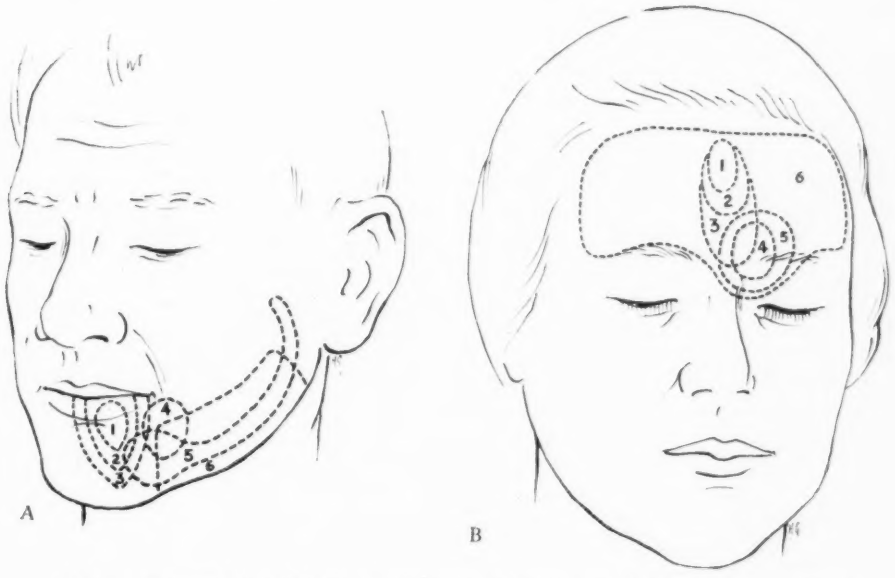


Fig. 9.—Topographic tabulations of recurrences in Cases 1 and 2 (*A* and *B*, respectively). The numbers indicate the order of recurrence, and the dotted line encompassing any number indicates the extent of surgery necessary to resect the recurrent growth.

viously adequately excised, new tumors must arise in a multicentric fashion along the nerve to give the false impression of metastatic disease. A topographic tabulation (Fig. 9*A* and *B*) of new tumor growths in the first two cases in this series demonstrates well the pattern of retrograde recurrence following removal of the initial subcutaneous nodule. At present there are no reliable criteria by which one can predict which cases will follow such a behavior pattern. It seems to us, then, that since the recurrent cases of various histologic gradation may have a clinical appearance similar to that in cases for which a wide excision is sufficient, to subject all patients to radical extirpation on the strength of the diagnosis alone would be excessive surgery. In addition, with microscopic evidence of adequate margins of excision of any specific tumorous growth, there is no logic in an even wider excision, since there is no assurance that in any specific instance this would be necessary or sufficient. Cases 3, 4, 5, and 7 support the contention that a single wide excision may suffice. It is true, though, that in two of these cases the tumors were well differentiated and ones which, in an extremity, Cutler and Gross feel could be treated by radical local excision provided the nerve of origin were excised. For more anaplastic lesions many feel there could be no such compromise. Certainly, if any amputation of an extremity is indicated, we believe that a generous amount of normal tissue should be sacrificed and the proximal nerve inspected at some length for synchronous growths. As it concerns the head and neck area we disagree, again because of the strategic location of the tumors.

We also feel that it would be unreasonably mutilating to attempt to dissect out any superficial nodule in an effort to identify or trace its nerve association in the hope that new tumors will be discovered along the course of the nerve. To attempt such an approach in, for example, Case 5 would prove futile, and cosmetically unnecessarily mutilating. The tumor was situated in the midline of the upper lip, making it impossible to decide on which side the

exploration should be continued. The same is true of the other cases in this group, including the ones which in retrospect had tumor reappearance locally after a wide excision. The notable exceptions were the first two cases in which in the course of management there developed evidence of involvement of a specific nerve (Fig. 2). In these instances the source of the recurrence was a distinct anatomic entity, and therapy could be more specific and aggressive.

In short, we have come to realize that, however we might agree with others on the various clinical aspects and behaviors of these tumors, the unique and strategic location of the superficial tumors reported herein makes it difficult or unreasonable to treat them as they would be treated in other areas of the body. We believe that subcutaneous neurofibrosarcomas of the head and neck should be treated by adequate local excision unless the nerve of origin can be demonstrated. Only in the latter circumstance is it reasonable to dissect the involved nerve widely and to resect the involved tissue in a radical manner.

Because of their location, it was understandable that the tumors of the deeper structures were larger than when first seen. In two of these patients (Cases 9 and 10) specific nerves were involved. It was thus possible in these two cases to excise the involved nerve en bloc with the anatomically adjacent structures. On microscopic examination there was demonstrated normal tissue at the extremes of excised nerves. In the other two patients (Cases 11 and 12) no specific nerves could be implicated; nevertheless, a wide en bloc resection of the tumor and adjacent normal tissue was performed. One of these patients required further surgery for a recurrent tumor. All are now without evidence of recurrent tumor, although in the most recent case operation was performed only two years ago. In no instance are there any indications that these tumors differ microscopically from the more superficial ones. As mentioned before, they were grossly larger and inferentially more difficult to eradicate. In all instances the tumor produced deformity by its own mass, and it was obvious not only that the contemplated radical surgery was the only procedure that could encompass the tumor in an attempt at curative surgery but that the resultant mutilation would hardly surpass the preoperative appearance. We believe the more favorable postoperative course of the tumors located in the deeper structures of the head and neck is a reflection of the feasibility of a more extensive surgical excision.

The two patients with associated generalized neurofibromatosis rightfully should be considered separately. It has been estimated[6,9,10] that 10% to 15% of the patients with this benign disease eventually have sarcomatous degeneration of one or more of their nodules. This is probably a high estimate, since many patients with occult, or even obvious, evidence of neurofibromatosis never come under the care of a physician. One of our patients had had 15 surgical procedures for the excision of tumors, up to 7 cm. in diameter. The excisions were performed because the nodules were enlarging rapidly, interfered with breathing and eating, or were extremely painful. On the last three occasions the excised tumors were neurofibrosarcomas. The other similar patient (Fig. 8) came to us after one previous operation; yet his tumor masses were nonresectable from the standpoint of cure. In these patients the most realistic management is that of excision of nodules only if they rapidly enlarge, become painful, interfere with vital functions, or are extremely disfiguring.

Summary and Conclusion

Fourteen cases of neurofibrosarcoma of cranial nerve origin are presented. A total of 32 operations have been performed on these patients. Ten patients are alive and without evidence of tumor, four having been free for over five years. One is alive

with known tumor, and two patients died of their disease. One patient died of intercurrent disease without evidence of neurofibrosarcoma. In two of the patients there was an associated neurofibromatosis.

In the absence of specific nerve involvement, subcutaneous neurofibrosarcomas of cranial nerve origin should be treated by adequate local excision. If the nerve can be identified, it should be exposed far beyond the tumor mass in a search for synchronous tumors and the nerve resected as far proximally as possible.

Neurofibrosarcomas involving more deeply situated nerves can be treated most effectively by an en bloc excision of the involved area plus further proximal excision of the nerve.

Neurofibrosarcomas have a high incidence of local recurrence. This is believed to be a manifestation of multicentric origin of tumors along the involved nerve.

These tumors metastasize through venous channels, and operations for their removal in the area in question should not be designed as for those lesions which metastasize predominantly through lymphatics.

There appears to be a correlation between the microscopic gradation of the tumor and the postoperative salvage. Likewise, tumors possessing a pseudocapsule have a more favorable prognosis.

Patients with generalized neurofibromatosis who develop neurofibrosarcoma have a uniformly poor prognosis.

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Major Blood Vessel Injury During Elective Surgery

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Injury to major blood vessels has been the subject of numerous reports, particularly during and after periods of international conflict. The papers of De Bakey and Simeone[1] and Rose and associates,[2] following World War II, and the report of Jahnke and Seeley[3] on vascular injuries in the Korean War are representative.

Previously reported major vessel injuries associated with elective surgical procedures include the aorta and iliac vessels,[4-8] the inferior vena cava,[9-11] and the superior vena cava.[12] The late complication of arteriovenous fistula following unrecognized operative injury has been noted by Elkin[13,14] and Glass and Ilgenfritz.[15]

The present report represents our combined experience in the management of 11 cases of major vascular injury arising during the course of elective operative procedures. The methods employed varied from ligation of the injured vessel to graft reconstruction. In two instances major arterial flow was reestablished by unusual techniques involving end-to-side implantation of the iliac artery and the utilization of the extensive cross facial-arterial anastomoses to maintain patency of the internal carotid artery.

A final consideration in the treatment of major arterial injury involves the use of blood vessel substitutes. Although some controversy exists regarding the role of arterial homografts, autologous venous grafts, and the synthetic materials, certain conclusions will be drawn regarding their individual application in major arterial reconstruction.

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Report of Cases

CASE 1.—This 42-year-old white woman sustained a 1 cm. laceration of the right axillary artery during the course of a radical mastectomy (June 23, 1949). Lateral arteriorrhaphy produced significant luminal distortion, and it was necessary to resect the injured arterial segment and perform end-to-end anastomosis. The pulses in the right arm were present postoperatively and have remained good during a six and one-half year follow-up period. There has been no recurrence of her breast tumor.

CASE 2.—This 37-year-old white woman had a hysterectomy on May 7, 1955, and, because of persistent and severe postoperative vaginal bleeding during the two weeks following this procedure, bilateral ligation of the internal iliac arteries was performed on May 21. During the course of this procedure the left common iliac artery was torn just below the aortic bifurcation. Two absorbable surgical (gut) transfixion sutures were placed to control the bleeding and the incision closed. At the completion of this procedure, her left leg was cold, white, and anesthetic. A reexploration was done approximately four hours later. The traumatized segment of the left common iliac artery was excised and the aortic end closed with a continuous 00000 silk suture. The distal left common iliac artery was anastomosed in end-to-side fashion to the medial side of the right common iliac artery approximately 1 cm. below the aortic bifurcation. The pulses returned in the left lower extremity, and her postoperative course was un-

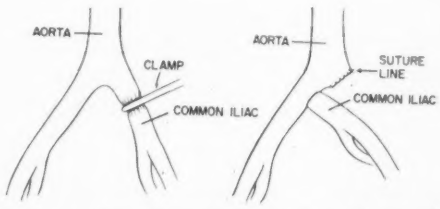

Fig. 1 (Case 2).—Artist's drawing of site of iliac artery injury and method of reconstruction.

eventful. Follow-up examination at 27 months revealed good pulses throughout the left leg.

Case 3.—This 37-year-old white woman had had a left radical mastectomy approximately 10 years prior to her present hospital admission. She was admitted for plastic correction of an adduction contracture of the left axilla. On May 1, 1956, a Z-plasty was attempted, but during this procedure major bleeding was encountered. This was controlled by a transfixion suture of gut. Four days postoperatively the patient fell out of bed, and a large hematoma immediately developed. Exploration revealed a laceration of the left axillary artery, which had been transfixed at the time of the plastic procedure upon the axilla. This segment was resected and an end-to-end anastomosis performed. Postoperatively pulses were present throughout the left upper extremity. Follow-up communication with the patient's physician 14 months later established that pulses were still present and that there were no ischemic symptoms in the left arm.

Case 4.—This 22-month-old white girl had a pharyngeal flap repair done for cleft palate on June 6, 1955. The following day she developed severe respiratory distress and an emergency tracheostomy was done. During this procedure the right common carotid artery was lacerated and the vessel was ligated. No attempt at reconstruction was made because of the patient's extremely poor general condition and the gross contamination of the cervical wound. No paralysis resulted. The patient died two days after the tracheostomy, and an autopsy by the medical examiner revealed aspiration pneumonia to be the cause of death. Examination of the brain was not done. Prior to death there was no evidence of clouding of the sensorium or motor dysfunction of the central nervous system.

Case 5.—This 65-year-old white man sustained a laceration of the left common carotid artery during a radical neck dissection for carcinoma of the larynx on Nov. 26, 1956. The lacerated segment of common carotid was excised and the proximal end closed with two ligatures of 00 silk. The distal point of division of the common carotid artery was approximately 10 mm. below the carotid bifurcation, and this end was closed with a continuous over-and-over to-and-fro suture of 00000 silk. This method of repair resulted in an intact segment of common carotid artery immediately below its bifurcation and allowed for free communication between the internal and the external carotid artery. At the time of repair, which was approximately two and one-half hours after injury, a thrombus had formed throughout most of the distal common carotid artery and was removed from the region of the arterial bifurcation. Because of the extensive dissection and flap construction coincidental to the radical neck dissection, no anticoagulants were used at the time of repair or

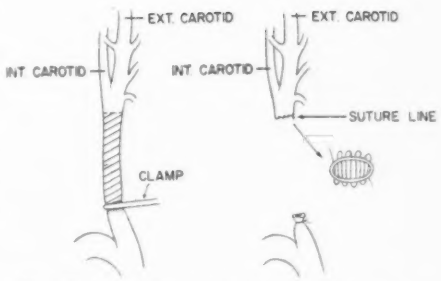

Fig. 2 (Case 5).—Artist's drawing of site of common carotid artery injury and method of reconstruction.

postoperatively. Pulsation was present in both the left internal and the left external carotid artery following excision and closure of the common carotid artery. The patient was last seen four months postoperatively, at which time pulsation in the left external and internal carotid arteries was easily palpable. There has been no interference with mentation and no evidence of motor paresis or paralysis.

Case 6.—This 48-year-old white woman was operated upon July 9, 1951, for an extensive carcinoma of the rectosigmoid. In dissecting the lesion from the left common iliac artery, the vessel was torn. The bleeding was controlled by a transfixion suture through the common iliac artery. Postoperatively the patient's left leg was cold, white, and painful. However, prompt improvement followed a sympathetic nerve block, elevation of the head of the bed, and application of reflex heat to the lower abdomen. The administration of heparin intravenously and subcutaneously resulted in further improvement in the appearance of the extremity and the relief of ischemic pain. The extremity remained viable and continued to improve on a conservative regimen. Although there was evidence of impairment of blood flow, as indicated by two-block intermittent claudication at the time of discharge from the hospital, this cleared within a short time, and for the ensuing two years walking distance was unlimited.

Case 7.—This 64-year-old white man sustained a laceration of his right subclavian artery during a radical neck dissection with laryngectomy, performed for carcinoma of the larynx on April 8, 1953. The bleeding was controlled by transfixion sutures. No attempt to reconstruct the artery was made because of the extensive primary tumor and the need to open the patient's chest to gain adequate proximal control of the subclavian artery. Furthermore, the color and temperature of the patient's right hand remained good following obliteration of the artery. The patient died four months later of metastatic lymph node involvement of the lung

TABLE 1.—*Injuries to the Axillary, Carotid, and Subclavian Arteries*

Case	Age	Sex	Date	Operation	Vessel Injured	Management	Pulses	Result
1	42	F	1949	Radial mastectomy	Axillary artery	End-to-end anastomosis	Yes	Recovery
3	37	F	1956	Z-plasty contracture of axilla	Axillary artery	End-to-end anastomosis	Yes	Recovery
4	22 mos	F	1955	Emergency tracheotomy	Common carotid artery	Ligation	No	Died 2 days later, aspir. pneum.
5	65	M	1956	Radical neck dissection	Common carotid artery	Ligation and preservation of carotid bifurcation	In both int. and ext. branches	Recovery
7	64	M	1953	Radical neck dissection	Subclavian artery	Ligation	No	Recovery

and trachea. During this four-month interval the upper extremity remained viable and with good functional tolerance.

Case 8.—This 45-year-old white woman sustained a laceration of the inferior vena cava during the course of a nephrectomy for hydronephrosis, on Nov. 8, 1956. The bleeding was initially controlled by the application of Kelly clamps to the inferior vena cava. Pott's clamps were then substituted for the Kelly clamps above and below the lacerations, and the openings in the inferior vena cava were repaired with a continuous suture of 00000 silk. The patient's postoperative course was uneventful, and at no time did edema of the lower extremities or thromboembolic phenomena occur.

Case 9.—This 59-year-old white man, during a secondary ureterostomy for calculi, on May 21, 1957, sustained an injury to the inferior vena cava. The bleeding was controlled with a Kelly clamp, which was left in situ until the next day, at which time the wound was reopened to repair the injured vessel. Repair was effected, and the search for the ureter was resumed. However, another laceration was made in the vena cava. This also was repaired and the urological procedure abandoned. At no time following operation did edema of the lower extremities or thromboembolic phenomena occur.

Case 10.—This 21-year-old white woman sustained an injury to the left common femoral artery during a varicose-vein ligation under spinal anesthesia, on Nov. 30, 1954. The bleeding was controlled by transfixion suture. She developed coldness, numbness, and severe pain in the left foot on reaction from her anesthesia. The incisions below the knee failed to heal. A bypass autologous saphenous-vein graft was inserted approximately three weeks later at the New York Hospital. The graft measured 18 cm. in length and was anastomosed in end-to-end fashion to the external iliac artery proximally and the superficial femoral artery distally. Postoperatively the dorsalis pedis and posterior tibial pulses returned, and the incisions in the lower leg healed secondarily. The circulation to the left leg has remained good during an 18-month follow-up period.

CASE 11.—This 30-year-old white man sustained complete transection of the right common femoral artery at the level of the inguinal ligament during the course of an inguinal hernioplasty on April 19, 1949. An immediate end-to-end anastomosis was done. The pulses in the extremity were absent postoperatively, and over the ensuing 16 hours the leg and foot became cold and white. Reexploration revealed stenosis of the arterial anastomotic site. This was resected and anastomosis again performed. After this procedure pulses returned, and the patient's course has been uneventful for a follow-up period of two years.

Comment

The present group of cases includes nine arterial injuries and two injuries to the inferior vena cava. The specific arteries involved include the subclavian (one), the axillary (two), the common carotid (two),

TABLE 2.—*Injuries to the Iliac and Femoral Arteries*

Case	Age	Sex	Date	Operation	Vessel Injured	Management	Pulses	Result
2	37	F	1955	Posthysterectomy bleeding	Common iliac artery	Ligation at aortic bifurcation; end-to-side left-to-right common iliac artery	Yes	Recovery
6	48	F	1951	Anterior resection	Common iliac artery	Ligation	No	2 yr. postop. good
10	21	F	1955	Varicose vein ligation	Common femoral artery	Delayed bypass vein graft	Yes	Recovery
11	29	M	1949	Right inguinal hernia	Common femoral artery	End-to-end anastomosis	Yes	Recovery

the common iliac (two), and the common femoral (two) (Tables 1 and 2).

Repair of the injured artery was performed in five cases. End-to-end anastomosis was done in three patients (Cases 1, 3, and 11), although in one (Case 11) a secondary anastomosis had to be performed because of thrombosis of the original repair. The two remaining patients in whom arterial restoration was successfully attempted were Cases 2 and 10. As noted in the case reports, techniques other than end-to-end anastomosis were employed in these two patients. The immediate and delayed reconstruction procedures in these five patients resulted in the return of peripheral arterial pulses and a normal extremity.

Ligation of an injured artery was performed four times in this series. In two patients (Cases 6 and 7) there was no evidence of significant ischemia following interruption of the major artery. In addition, the extreme nature of the malignant disease in Case 7 appeared to preclude the extensive operative procedure necessary for reconstruction. In neither of these cases did tissue loss or severe incapacity result from this conservative management. Ligation of the common carotid artery was felt to be mandatory in Case 4, not only because of the patient's terminal condition but also because of the gross contamination of the tracheostomy wound. The final case in which ligation was done was Case 5, and in this instance continuity from the external carotid to the internal carotid artery was maintained by suturing the stump of the common carotid artery 1 cm. proximal to its bifurcation. The outcome was favorable.

The two instances of injury to a major vein involved the inferior vena cava and occurred during the course of urological operations (Table 3). In both (Cases 8 and 9) lateral repair was effected with a satisfactory result, as determined by the absence of bleeding and the failure of edema characteristic of inferior vena caval thrombosis to develop.

The use of vascular grafts and prostheses is an ever-present consideration in the reconstruction of arterial injuries. The immediate arterial injury or the attempted control of bleeding may result in injury so extensive that lateral repair or end-to-end anastomosis is impossible. We have found the autologous vein graft to be an eminently satisfactory graft in peripheral arterial reconstruction. We have recently reported our experience in the use of 12 such grafts for peripheral reconstruction following arterial injury (five cases), in arterial aneurysm and arteriovenous fistula (six cases), and during the course of resection of a malignant tumor of the groin (one case).[16] These grafts have remained patent for as long as seven years and have shown no evidence of aneurysmal dilatation. All were introduced into an arterial tree without distal obstruction. We feel that these grafts are inherently more satisfactory for peripheral reconstruction, for many reasons. These include the elimination of the problems of procurement, sterilization, and preservation inherent in the use of homologous arteries. The autologous vein is totally free of the antigenic potential inherent in an arterial graft. Recent studies in our laboratory indicate that immune reactions in patients following the insertion of homologous arterial and aortic grafts are common.[17] In addition, Szilagyi [18] has studied the histological appearance of aortic and femoral arterial homografts at varying intervals following their insertion in humans. The only portion of the graft that remains intact is the elastic fibers, the remaining components of

TABLE 3.—*Injuries to the Inferior Vena Cava*

Case	Age	Sex	Date	Operation	Vessel Injured	Management	Pulses	Result
8	45	F	1956	Nephrectomy	Inferior vena cava	Repair of defect	..	Full recovery
9	63	M	1957	Secondary ureterostomy	Inferior vena cava	Repair of defect	..	Full recovery

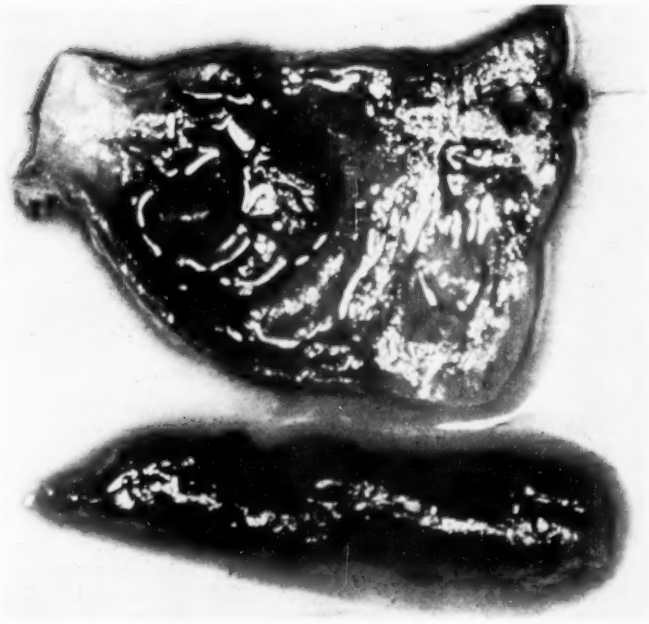

Fig. 3.—Appearance of arterial homograft and thrombus 24 months after insertion. This graft had remained patent for 23 months. The proximal half of the graft is not shown in this photograph.

the wall being invaded by connective tissue. In peripheral arteries suitable for use as grafts the presence of elastic tissue is minimal, and the predominant smooth-muscle component is rapidly replaced by collagen of low tensile strength. This behavior is in direct contrast to the vein graft, which survives as a viable unit with intact elastic and muscular components. One of us (P. W. S.) has recently had the experience of thrombosis in an 8 cm. arterial homograft inserted into a subclavian and axillary arterial defect. This graft functioned well for 23 months and then became thrombosed. At operation the graft was found to be uniformly dilated (two to three times) and filled with thrombus (Fig. 3). Microscopic examination showed complete loss of

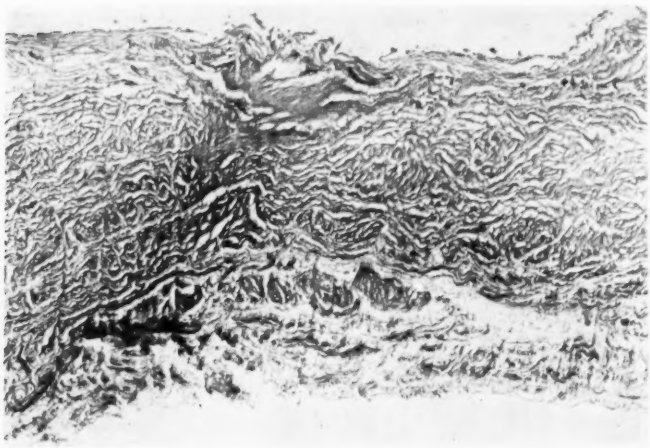

Fig. 4.—Photomicrograph of arterial homograft shown in Figure 3. Note loss of intima and elastic-tissue components of graft wall. Van Gieson elastic tissue stain; reduced to 63% of mag. × 55.

all elastic and muscular components in its wall (Fig. 4). Coincidentally this patient had a marked cutaneous immune reaction to antigen prepared from human aorta. The final indictment of the preserved arterial homograft would appear to be calcification and the deposition of cholesterol, producing atherosclerotic changes within the graft itself.[19] Jones and Dale[20] have reported upon the experimental insertion of autologous venous bypass grafts in dogs. They noted no dilatation, aneurysmal formation, or perforation and conclude that the often-cited failures of venous grafts are related chiefly to venous replacement of a large vessel such as the aorta.

With respect to aortic and iliac arterial replacement, we believe that the material of choice is one of the currently available synthetic prostheses. The recent report of the Committee for the Study of Vascular Prostheses of the Society for Vascular Surgery indicates that these materials were successful in 93% of 256 cases of aorto-iliac replacement.[21] Prosthetics made of Dacron have proved most satisfactory in our hands and are commercially available.* Unquestionably, further improvement will take place in this field, as the presently available products leave much to be desired.

Ancillary supportive techniques which are of value in the management of a critically ischemic extremity include elevation of the head of the bed to promote gravity flow, the application of heat to the lower abdomen to promote reflex vasodilatation, and the use of anticoagulants to prevent propagation of a thrombus, with the obliteration of adjacent collaterals. The use of paravertebral sympathetic block and vasodilators may also favorably influence the outcome. The above measures may prove of great value in salvaging a critically ischemic limb, in which, for one of several reasons, reconstruction cannot be accomplished.

* Ethi-graft, Johnson & Johnson, New Brunswick, N. J.

Summary

The surgical literature contains a number of excellent papers dealing with the management of arterial injury incurred in wartime, but reports of major blood vessel injury in the course of elective surgery are infrequent. A series of nine major arterial injuries and two instances of inferior vena caval laceration is presented. The methods employed in the management of these cases are discussed.

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Hyperfunction of Gastric Antrum Following Vagotomy and Pyloroplasty

EDWARD R. WOODWARD, M.D., Los Angeles

The hypersecretion of acid gastric juice, characteristic of the patient with duodenal ulcer, is abolished by complete division of the vagus nerves to the stomach. The interruption of the nervous phase of gastric secretion is generally considered to be the basic principle accounting for the favorable therapeutic results obtained by this method. Unfortunately, vagotomy also exerts a potent influence on gastric motor activity, and the need for an ancillary drainage procedure is apparent. Gastroenterostomy has been widely used for this purpose and has been successful in promoting adequate emptying of the vagotomized stomach. Prominent among disadvantages of this procedure is the interference with normal, acid-base control of the antral "gastrin" mechanism. Reflux of alkaline duodenal fluids promotes the excessive release of the gastric hormone; this is influenced to a large extent by the location and size of the gastrojejunal stoma.[1-4] A high-lying gastrojejunostomy promotes retention in the dilated vagotomized distal portion of the stomach, allowing excessive chemical and mechanical stimulation of the gastric antrum. Oberhelman and Dragstedt[5] have indicted this mechanism as a cause of recurrent peptic ulceration in patients known to have complete vagotomy.

The use of pyloroplasty as an adjunct to vagotomy has both practical and theoretical advantages. The operation is technically simpler, and normal gastrointestinal continuity is preserved. The unpleasant symptom complex known as the dumping syndrome is occasionally seen with gastrojejunostomy but rarely occurs after pyloroplasty. In the experimental laboratory, it has been found that pyloroplasty does not exaggerate the gastric phase of gastric secretion as does gastrojejunostomy.[6] Weinberg[7] has advocated this procedure and has used a modification of the Heinecke-Mikulicz pyloroplasty which avoids the obstruction resulting from excessive infolding of tissue at the suture line.

One theoretical, anatomical handicap of pyloroplasty is the fixation of the pyloric region in the upper abdomen, necessitating, at least to some extent, "uphill" emptying of the vagotomized stomach. Although x-ray examination frequently discloses some retention of the barium meal in these patients, clinically in almost all of them the stomach seems to empty satisfactorily. However, we have recently seen three patients in whom recurrent peptic ulcer disease occurred after pyloroplasty plus physiologically proved complete vagotomy.

Report of Cases

CASE 1.—A 34-year-old white man, a sheet metal worker, was admitted to Wadsworth General Hospital on Aug. 12, 1955. The patient had a history of typical ulcer distress of 20 years' duration. In 1944 he had had a massive upper gastrointestinal hemorrhage, and in 1955, three months prior to admission, he had suffered a perforated duodenal ulcer, which was closed surgically. After recovery, severe ulcer symptoms recurred despite medical therapy. After hospitalization severe symptoms persisted, and the patient was transferred to the surgical service. On Sept. 6, 1955, vagotomy and

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pyloroplasty were performed. During the postoperative period the patient developed periodic diarrhea, which persisted after discharge from the hospital. Six weeks after operation, the patient began periodic vomiting of undigested food. Shortly thereafter, he noted the onset of nearly constant burning epigastric pain, resembling his previous ulcer distress and only partially relieved by the taking of milk or alkali. He noted the sensation of abdominal fullness throughout this period. X-ray examinations revealed a large, somewhat atonic stomach with approximately 25% retention of the barium meal after four hours. No definite crater in the stomach or duodenum was demonstrated.

A Levin tube was passed into the stomach following a fast of 18 hours. Two hundred sixty cubic centimeters of gastric juice mixed with partially digested food was aspirated; the pH was 1.6. The patient's symptoms were immediately relieved. After evacuation of the stomach, basal gastric secretion determination over a period of four hours revealed a low secretory rate, averaging 52 cc. per hour, with no free acid observed at any time. The minimum pH observed was 5.7.

On two occasions, hypoglycemia was induced by administering 20 units of regular (amorphous) insulin intravenously. No augmentation of the secretory rate ensued, and no free acid appeared at any time. There was a brisk secretory response to subcutaneous histamine (50 mg. of betazole hydrochloride [Histalog]), with the free acid reaching 66 clinical units; the pH was 1.4. Two hundred cubic centimeters of N/10 HCl, introduced by stomach tube, resulted in the same epigastric distress which had been present clinically.

On Jan. 4, 1956, a Levin tube was passed into the stomach after 18 hours of fasting and the residual fluid aspirated. The patient was then given a breakfast consisting of one glass of orange juice, one poached egg, one slice of toast, two strips of bacon, and one glass of milk. Samples of gastric content were aspirated each 30 minutes for pH determination; the results are presented in Table 1. After one hour, the pH fell to 3.0 from the fasting level of 6.3. Two hours after breakfast, the gastric pH was 1.7, with 42 clinical units of free acid present. Three and one-half hours after breakfast, the pH began to rise, and free acid disappeared.

On Jan. 18, 1956, exploration was again done. Although no external evidence of peptic ulcer could be found, it was thought advisable to resect the gastric antrum. Gastrointestinal continuity was restored with a Shoemaker-Billroth I gastroduodenostomy. The resected specimen measured 8 cm. on the lesser curvature and 13 cm. on the greater curvature. No crater was present, but grossly the mucosa of this part of the stomach was edematous, indurated, and beefy red in color. The microscopic diagnosis was chronic gastritis.

The patient's postoperative recovery was entirely uneventful. On Feb. 3, 1956, gastric secretory studies were repeated. The basal gastric secretion, as before, showed no free acid, and no gastric retention was found. The response to histamine stimulation (50 mg. betazole hydrochloride) was relatively unchanged, with the pH falling to 1.4 and the free acid rising to 47 clinical units. The patient was given the same test breakfast as before antrum resection, and the results are presented in Table 2. After two hours, the pH fell from the fasting level of 5.6 to a minimum of 3.1, but no free acid appeared at any time.

The patient's epigastric distress was entirely relieved. Now, one and one-half years after operation, the patient is back at his usual occupation and has felt entirely well on an unrestricted diet without medication.

CASE 2.—The patient, a 45-year-old white man, a commercial artist, was admitted to the Wadsworth General Hospital, March 29, 1955. He had first developed epigastric pain two years before, associated with nausea and vomiting. X-ray examination at that time disclosed a duodenal ulcer, and he was placed on medical treatment, with satisfactory relief. However, recurrence of pain ensued one year prior to admission. He had a bout of hematemesis and melena, not requiring transfusion. In the hospital, maximal medical therapy

TABLE 1.—*Response to Test Meal Before Antrectomy*

Time, Min.	pH	Free Acid, Clinical Units
0840	5.9	0
0855	6.3	0
Test breakfast eaten		
0910	6.3	0
0940	6.1	0
1010	5.4	0
1040	3.0	0
1110	1.7	42
1140	1.9	24
1210	1.5	19
1240	3.7	0
1310	2.8	0

TABLE 2.—*Response to Test Meal After Antrectomy*

Time, Min.	pH	Free Acid, Clinical Units
0830	5.4	0
Test breakfast eaten		
0845	5.6	0
0915	5.5	0
0945	5.5	0
1015	4.1	0
1045	4.1	0
1115	3.3	0
1145	3.1	0
1215	3.7	0
1245	5.4	0
1315	5.2	0

gave only partial symptomatic relief. Therefore, the patient was transferred to the surgical service, and on April 12, 1955, vagotomy and pyloroplasty were performed. Postoperative recovery was uneventful, except that the patient had rather severe dysphagia, persisting for three weeks.

Soon after discharge from the hospital, the patient developed recurrence of his typical epigastric pain, resulting in his readmission to the hospital on June 1, 1955. Medical therapy produced no significant amelioration of his symptoms. X-ray examination disclosed approximately 50% retention of the ingested barium after four hours. The stomach was atonic and moderately dilated. No definite crater could be made out in either stomach or duodenum.

Gastric secretory studies disclosed a negative response to insulin-induced hypoglycemia on two occasions. Basal gastric secretion, which had been moderately elevated prior to this operation (2.77 mEq. per hour, *vs.* a normal average of 1 mEq. per hour and a duodenal-ulcer average of 5 mEq. per hour), was rather high in volume but showed no free acid. The response to test meal and histamine stimulation was brisk.

Because of persistence of symptoms, reexploration was done on June 22, 1955. A questionable area was palpated on the midportion of the lesser curvature, and therefore a two-thirds distal partial gastrectomy with a Shoemaker-Billroth I gastroduodenostomy was performed. The resected specimen measured 15 cm. on the lesser curvature and 27 cm. on the greater. On the lesser curvature, 4 cm. distal to the proximal line of resection, was a partially healed benign ulcer crater, measuring 1.5 cm. at its greatest diameter.

The patient's postoperative recovery was uneventful. Since his discharge from the hospital, he has remained a rather severe nutritive problem; but at the present time, one and one-half years after the second operation, there has been no recurrence of peptic ulcer.

CASE 3.—A 32-year-old white man, a factory guard, was admitted to Wadsworth General Hospital on March 15, 1954. In 1951 the patient had had vagotomy and gastroenterostomy performed because of intractable duodenal ulcer, complicated by hemorrhage and obstruction. Although completely relieved of his ulcer difficulties, the patient developed a severe dumping syndrome, with resultant loss in weight and considerable difficulty in maintaining employment. On three occasions, the basal gastric secretion showed no free acid in any sample, and on each of the three occasions the induction of insulin hypoglycemia showed a complete absence of a secretory response, indicating complete vagotomy. Therefore, on March 23, 1954, the gastroenterostomy was taken down and pyloroplasty performed. Soon the patient began to have the occasional vomiting of ingested food. This progressed in severity; the patient began to lose weight, and in December, 1954, he began having severe, burning epigastric distress, only temporarily and partially relieved by the ingestion of alkali. The patient was readmitted to the hospital on Dec. 6, 1954. X-ray examination disclosed high-grade gastric retention and a dilated, atonic stomach. There was an approximately 75% six-hour retention of barium. No definite crater was visualized in either stomach or duodenum because of interference by retained secretion.

After 18 hours of fasting, a Levin tube was placed in the stomach, and the residual fluid aspirated consisted of 650 cc. of gastric juice mixed with old food. The free-acid concentration was 30 clinical units. Aspiration resulted in complete relief of symptoms for the first time in several weeks. Continuous suction of the empty stomach disclosed a volume of 25 cc. per hour, with no free acid in any sample. The insulin gastric analysis was again negative.

On Jan. 15, 1955, reexploration was done. High-grade stenosis was found at and immediately distal to the point of pyloroplasty. It was felt that the pyloroplasty had not sufficiently divided the scar tissue resulting from the original duodenal ulcer. The gastric antrum was resected, and gastrointestinal continuity was restored with a Shoemaker-Billroth I gastroduodenostomy.

The gross surgical specimen of the resected stomach measured 10.5 cm. on the lesser curvature and 21 cm. on the greater curvature. On the lesser curvature, 2 cm. from the pyloroplasty suture line, was a chronic benign gastric ulcer, measuring 0.5 cm. in diameter and 0.1 cm. in depth, with surrounding edema and fibrosis. Microscopic examination confirmed the benignity of the lesion.

The patient made an uneventful postoperative recovery except for superficial wound infection, which delayed convalescence. He was discharged from the hospital on Jan. 31, 1955. He has been completely relieved of his epigastric distress and has had no further obstructive symptoms. Fortunately, two and one-half years later, the symptoms of the dumping syndrome have returned to only a mild degree, not interferring with nutrition or employability.

Comment

Three cases are presented in which recurrent pain of gastric origin following vagotomy and pyloroplasty required further surgical therapy. All three patients showed x-ray evidence of gastric retention, although only one had any significant degree of anatomical obstruction at the gas-

tric outlet. In all three patients, the retained gastric content had a moderately high free-acid concentration, although once the stomach was evacuated, basal gastric secretion was low, with an absence of free acid. In all patients there was repeated absence of a gastric secretory response to insulin-induced hypoglycemia.

In dogs prepared with Heidenhain pouches to serve as indicators of gastrin formation, the division of the vagus nerve to the main stomach will result in hypersecretion of gastric juice from the isolated denervated fundic pouch.[7] This effect of vagotomy is abolished if the antrum of the main stomach is first resected, indicating that the excessive secretion is mediated by the pyloric antrum. Furthermore, if an adequate drainage procedure, either gastroenterostomy or pyloroplasty, is performed in the main stomach, division of the vagi will not increase the Heidenhain pouch secretion. It is apparent, therefore, that retention of food and digestive juices within the stomach produced by the suppression of motility after vagotomy is the causative factor. It is probable that the long contact of food substances caused continued chemical stimulation of the antral mucosa to release gastrin, and also that the distention of the antrum resulting from the gastric retention causes mechanical stimulation of the gastrin mechanism. It has been shown that the gastric phase of gastric secretion will continue under such circumstances until the pH drops to a critical level of 1.2 to 1.5.[8,9] This undoubtedly accounts for the moderately high levels of free acid encountered at the time the stomach was originally aspirated in the three patients herein reported.

In all three patients, the same operative procedure was performed, namely, distal partial gastrectomy with a Shoemaker-Billroth I gastroduodenostomy. It seems very likely that a different drainage procedure, for example, gastroenterostomy, would have been sufficient in all three cases; however, since gastroenterostomy itself may excite gastrin release, it was felt that a favorable result would be less certain.

In two of the three patients reported, the Heinecke-Mikulicz pyloroplasty had resulted in a widely patent lumen between stomach and duodenum. The retention, therefore, was not on an anatomical basis but was, we feel, due to the hypotonic vagotomized stomach failing to empty itself "uphill," past the open pylorus fixed in the upper abdomen. For both technical and physiological reasons, pyloroplasty has definite theoretical advantages over gastroenterostomy as an adjunct to vagotomy. Only the question as to how often the former procedure fails to drain a vagotomized stomach adequately remains. The three cases herein reported constitute a tiny fraction of the patients with duodenal ulcer who were treated by vagotomy and pyloroplasty during the last three years at Wadsworth General Hospital. We feel, therefore, that this syndrome is a somewhat unusual occurrence, but one which will be inevitably observed in a certain few cases.

Nearly all these patients will require further surgery, since there seems to be no spontaneous tendency toward remission, and response to medical therapy is poor. Cholinergic drugs might conceivably help in gastric emptying where no anatomical obstruction is present, but these drugs will also stimulate acid production, and we feel this would drastically limit their utility. In our estimation, the procedure of antrum resection with a Billroth I reconstruction is the one most certain to succeed on theoretical grounds, and in practice the one which has been successful in the three cases recorded. Further resection of the stomach is not necessary, since the vagotomy is known to be complete and the recurrent secretion of acid has been entirely due to the gastrin mechanism.

Summary and Conclusions

Three cases are presented in which vagotomy and pyloroplasty for duodenal ulcer were followed by recurrence of the gastric

pain, necessitating further surgery. Two patients had gastric ulcer, and the third, antral gastritis.

All three patients had persistent negative responses to insulin-induced hypoglycemia, indicating satisfactorily complete vagotomy. This was an important requisite for the development of the syndrome, since the vagotomized stomach fails to empty adequately in these cases despite an open pylorus. Retention in the stomach causes hyperstimulation of the gastric phase of gastric secretion, with resultant hyperacidity of hormonal origin.

Treatment utilized in all cases was gastric resection. Since the acid being formed results from the gastrin mechanism, resection of the gastric antrum only is all that is required.

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Scientific Exhibits

A New Method for Evaluating Portal Hypertension

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HEMODYNAMICS

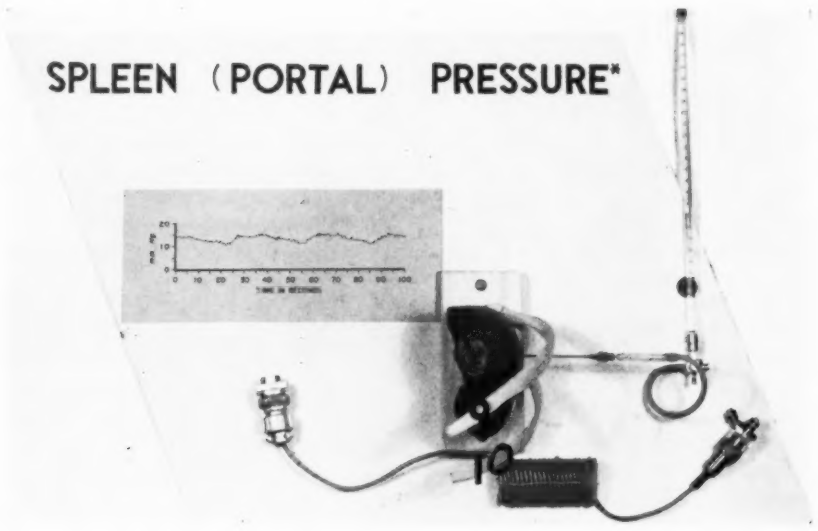

Fig. 1.—Splenic tissue pressure is a satisfactory index of portal venous pressure.[1,2] This pressure varies only slightly throughout the splenic pulp.[1] A standard approach to the spleen is used. With the patient supine on the x-ray unit, a #15-gauge needle, scored at 1.0 cm. intervals, is introduced under local anesthesia, through the left ninth intercostal space in the posterior axillary line. When the spleen is large, the 10th interspace in the midaxillary line is preferred. With the first flow of splenic blood (usually at 3-4.0 cm. from the skin surface), the needle is advanced an additional 3.0 cm., or as close to the hilus as possible. Pressures are recorded by manometer or strain gauge at needle or "splenostatic" level. These may be corrected to right atrial or prevertebral levels by utilizing a mean location of 5.0 cm. below the angle of Louis, or 12.0 cm. anterior to the horizontal spine or table level. The pressures recorded in this exhibit are uncorrected and represent the medians of three consecutive levels of fluid or the midpoint of extremes of a continuous tracing at the level of the needle.

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Veterans' Administration Hospital and the University of Pittsburgh School of Medicine.

Shown as scientific exhibit of the Section on Surgery, General and Abdominal, at the 106th Annual Meeting of the American Medical Association, New York, June 3-7, 1957.

ANATOMY

Fig. 2.—Serial portography* provides some evaluation of the preferential direction of portal flow and the number, size, character, and location of major portal branches and collateral veins. Forty cubic centimeters of 70% sodium acetrizoate (Urokon Sodium) or 50% diatrizoate sodium (Hypaque Sodium), is introduced manually in an injection phase of four to six seconds. Seven films are taken at one-second intervals, beginning midway through the injection. Slow, shallow breathing is permitted.

Note that the extent of collateralization is more clearly defined in the late films. The absence of diffuse opacification of the liver is consistent with intrahepatic portal obstruction and (in our experience) correlates well with liver biopsies that are positive for parenchymal pathology. The technical roentgen data are as follows: amperage, 200 mamp.; time, 0.1 to 0.3 second; kilovoltage, twice the AP diameter of the patient, in centimeters plus 35.

* Sanchez-Perez Automatic Seriograph.

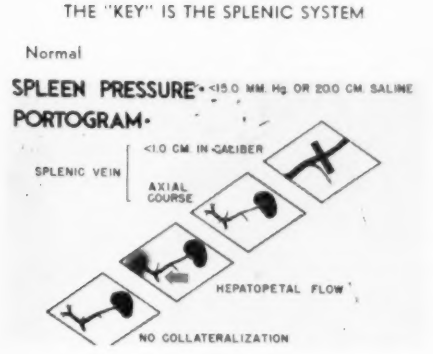

Fig. 3.—When the median "splenostatic" tissue pressures were below 15 mm. Hg (20.0 cm. of saline), splenomegaly and esophageal varices were not present on physical examination. In addition, the portogram revealed little or no evidence of "hypertensive" anatomy, and the dye flow was directly through the liver, i. e., "hepatopetal" flow.[8] The splenic veins, despite the 15% roentgen magnification factor, were invariably less than 1.0 cm. in diameter. This "key" vein rather consistently maintained an "axial," or undeviated, course from the hilus to the origin of the portal vein, and the dye never entered other portal branches or opacified collateral veins.

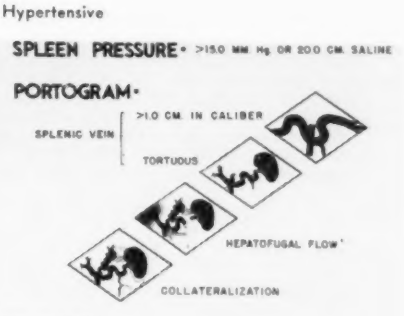

Fig. 4.—When spleen pressures exceeded 15.0 mm. of Hg (20.0 cm. of saline), the portogram revealed varying degrees of anatomical response to the blockaded flow. The splenic vein was greater than 1.0 cm. in caliber, frequently deviated from its axial course, and the dye entered branches of the splenic vein, i. e., "hepatofugal" flow.[8] If the coronary and short gastric venous systems were the only splenic branches opacified, such patients invariably demonstrate varices on esophagoscopy, even though they were not visualized on the portograms.

This is a *critical* observation, for when the predominant flow was in this direction (and not through branches of the inferior mesenteric vein) hemorrhage from varices was usually recurrent and massive (Figs. 10A and 10B).

PATTERN OF SPLENIC HYPERTENSION WITH LIVER DISEASE

Fatty Liver
Periportal Fibrosis
Cirrhosis
> 100 observations
70 patients

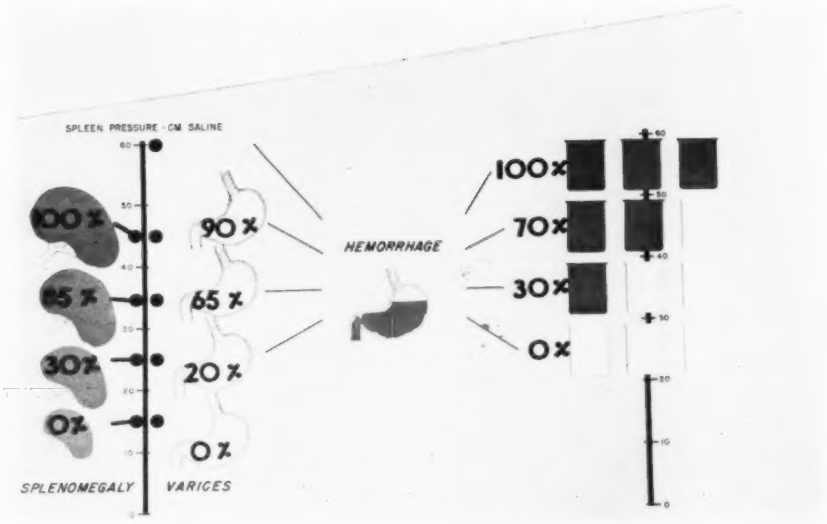

Fig. 5.—Static pressure measurements leave much to be desired in the understanding of the hypertensive syndrome. With the method described, the actual rate of flow is not measured, so that resistance cannot be estimated. However, the interrelationship of the clinical pattern of portal hypertension to static spleen pressure in a basilar state is apparently valid. As higher pressures are recorded, the spleen is always enlarged, and an increasing number of patients develop varices. A high tissue pressure in the absence of esophageal varices was demonstrated in a small group. The portogram revealed the reason, i. e., a nearly total absence of flow through a coronary-to-azygos system. In these patients the dye is principally found in the inferior mesenteric system or its branches, suggesting that patients without an available coronary collateralization have a self-protecting device against the development of varices. Bleeding from varices in our experience has not occurred with spleen pressures below 30.0 cm. With higher elevations the incidence of hemorrhage was directly related to spleen tissue pressure *when varices were proved to be present.*

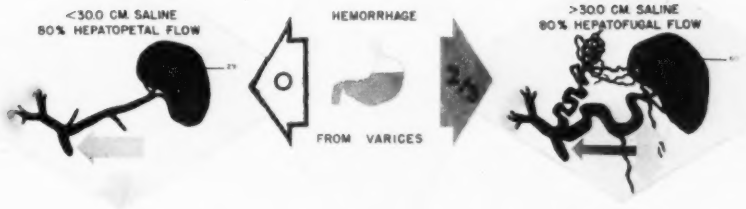

Fig. 6.—There is considerable individual response to obstructed portal flow. The site of the obstruction, the ultimate degree of elevation, and the number of available and draining collateral routes individualize the pattern found in each patient. We think that as these collaterals develop and become efficient, static pressures are probably scaled downward. Only serial studies over a period of months or years may confirm this assumption. However, if varices appear during the period of collateral development, the danger of hemorrhage is never obviated. "Hepatofugal" flow developed in 80% of our patients with spleen pressures over 30.0 cm. of saline. Two-thirds of these had had hemorrhages. Where pressures were below 30.0 cm., 80% had their flow principally through the liver. In this and in subsequent panels, the direction and size of the arrows conform to a crude estimate of the direction and volume of flow as suggested on the portograms.

SAMPLE STUDIES
INTRAHEPATIC OBSTRUCTION

Normal

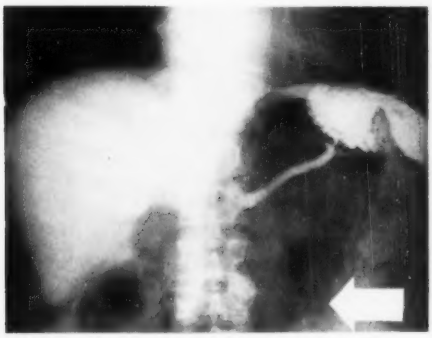

Fig. 7.—Patient A
Splenomegaly: 0
Varices: 0
Spleen pressure: 19.0 cm.
Splenic vein: 0.8 cm.
Axial
No collateralization
Flow pattern: Hepatopetal
G. I. hemorrhage: Yes (etiology unknown)
This "hepatogram" is characteristic of normal sinusoidal opacification and occurs within less than seven to eight seconds following the start of the injection. This is "hepatopetal" flow.

Fatty Liver

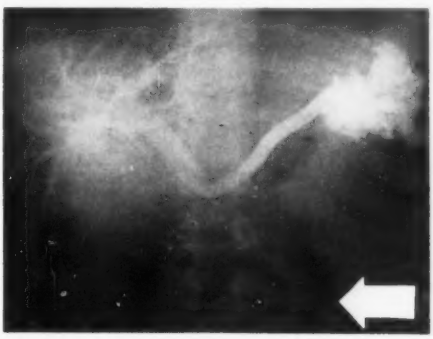

Fig. 8.—Patient B
Splenomegaly: 0
Varices: 0
Spleen pressure: 26.0 cm.
Splenic vein: 1.0 cm.
Axial
No collateralization
Flow pattern: Hepatopetal
G. I. hemorrhage: No
Except for the absence of an early or prompt hepatogram and a large splenic vein, this study is normal.

Cirrhosis

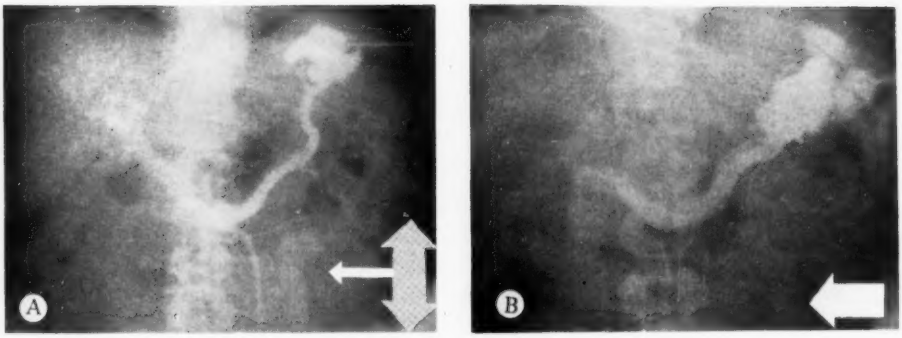

Fig. 9A.—Patient C (preshunt); 5/3/55
Splenomegaly: +
Varices: +
Spleen pressure: 52.0 cm.
Splenic vein: 1.5 cm.
Tortuous
Collateralization & gastric varices
Flow pattern: Hepatofugal
G. I. hemorrhage: Yes
Small gastric varices and a large inferior mesenteric vein are opacified.

Fig. 9B.—Patient C (postshunt); 9/22/55
Splenomegaly: 0
Varices: + (collapsed)
Spleen pressure: 27.0 cm.
Splenic vein: 1.7 cm.
Slightly tortuous
No collateralization
Flow pattern: Portocaval
G. I. hemorrhage: No (9/3/56)
Following the shunt there is considerable drop in spleen pressure.

INTRAHEPATIC OBSTRUCTION

Cirrhosis and Caval Obstruction

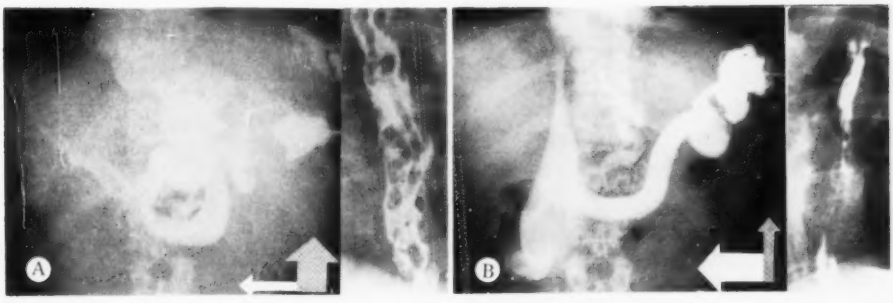

Fig. 10A.—Patient D (preshunt); 5/4/56
Splenomegaly: +
Varices: +
Spleen pressure: 35.0 cm.
Splenic vein: 1.9 cm.
Tortuous
Collateralization & varices
Flow pattern: Hepatofugal
G. I. hemorrhage: Yes
The coronary system, here, represents the sole route for "hepatofugal" flow. Giant varices involve more than two-thirds of the esophagus and fill the mediastinum.

Fig. 10B.—Patient D (postshunt); 8/4/56
Splenomegaly: +/0
Varices: + (collapsed)
Spleen pressure: 38.0 cm.
Splenic vein: 1.7 cm.
Slightly tortuous
Slight collateralization
Flow pattern: Portocaval
G. I. hemorrhage: None (5/1/57)
The intrahepatic vena cava is compromised, and consequently the spleen pressure remains elevated despite the shunt. However, the coronary flow is markedly reduced, and the varices are identified with some difficulty.

Wilson's Disease

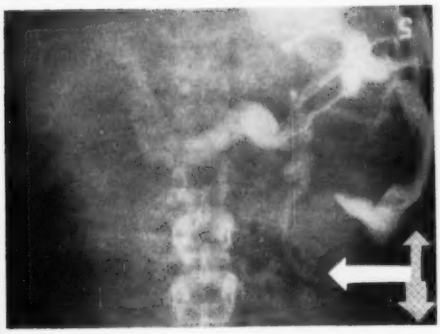

Fig. 11.—Patient E.
Splenomegaly: +
Varices: +
Spleen pressure: 30.0 cm.
Splenic vein: 1.8 cm.
Tortuous
Collateralization
Flow pattern: Hepatofugal & hepatopetal
G. I. hemorrhage: No
In three similar studies of this disease, the wedged hepatic venous pressure was also low or normal. This suggests intrahepatic, presinusoidal block rather than the postsinusoidal block characteristic of alcoholic cirrhosis.[4]

Hemochromatosis

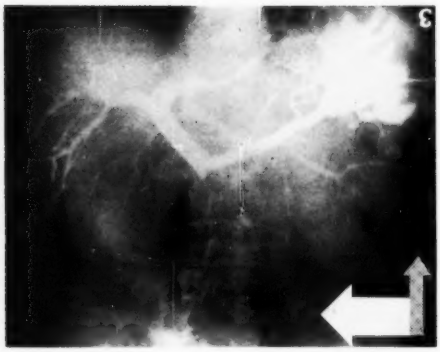

Fig. 12.—Patient F
Splenomegaly: +
Varices: + (gastric)
Spleen pressure: 38.0 cm.
Splenic vein: 1.0 cm.
Nontortuous
Collateralization with gastric varices
Flow pattern: Hepatofugal
G. I. hemorrhage: Yes
Although esophageal varices were not demonstrated in this patient, gastric varices appear on the portogram.

EXTRAHEPATIC OBSTRUCTION

Portal Vein Thrombosis

Fig. 13.—Patient G
Splenomegaly: +
Varices: +
Spleen pressure: 40.0 cm.
Wedged hepatic pressure: 12.0 cm.
Splenic vein: 1.5 cm.
Tortuous
Collateralization & varices
Flow pattern: Hepatofugal
G. I. hemorrhage: No
The incomplete filling of the portal vein is the "ground-glass" sign of Rousselot.[3] However, the normal wedged hepatic pressure is the final clue to the diagnosis of portal vein thrombosis.

Heart Disease (Ebstein's)

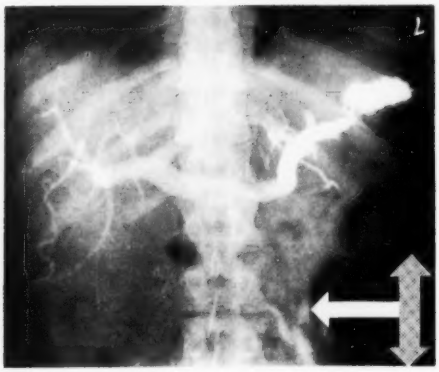

Fig. 14.—Patient H
Splenomegaly: +
Varices: +/0
Spleen pressure: 48.0 cm.
Peripheral venous pressure: 24.0 cm.
Splenic vein: 1.6 cm.
Tortuous
Collateralization & varices
Flow pattern: Hepatopetal & hepatofugal
G. I. hemorrhage: No
Gastric varices are demonstrated in this patient with congenital tricuspid valvular displacement.

Carcinoma of Pancreas

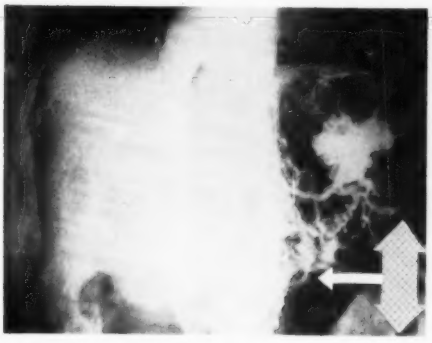

Fig. 15.—Patient I
Splenomegaly: 0
Varices: 0
Spleen pressure: 32.0 cm.
Splenic vein: Completely obstructed by tumor
Flow pattern: Hepatofugal & portocaval
G. I. hemorrhage: No
With occlusion of the splenic vein by tumor, the dye is shunted into the cava through the adrenal and renal systems. No varices were demonstrated and the spleen pressure is not seriously elevated.

Pyelothrombophlebitis

Fig. 16.—Patient J
Splenomegaly: 0
Varices: 0
Spleen pressure: 33.0 cm.
Splenic vein: Not identified
Collateralization
Flow pattern: Hepatofugal & splenocaval
G. I. hemorrhage: No
The portal and splenic veins are barely visible, since thrombosis is nearly complete. Dye is present in the vena cava. Again, with this type of natural and efficient adrenal-renal shunting, varices had not developed.

PRESENT STATUS OF SPLEEN PRESSURE—PORTOGRAPHY STUDY

ADVANTAGES	DISADVANTAGES
IMMEDIATE DIAGNOSTIC INFORMATION	PATIENT IS HOSPITALIZED
PERCUTANEOUS TECHNIQUE	FREQUENTLY PAINFUL (>50%)
LOCAL ANESTHESIA	SPLENIC HEMORRHAGE (>200 CC)
NO LAPAROTOMY	"FUNCTIONING SPLEEN" NECESSARY
NOT TIME CONSUMING	OTHER SIMILAR TESTS NOT REPLACED (i.e. WEDGED HEPATIC VEIN STUDIES)
MAY BE REPEATED	OCCASIONALLY DYE FILLS VEINS POORLY (10%-15%)

INDICATIONS	CONTRAINDICATIONS
DIAGNOSTIC STUDIES: LIVER SPLEEN PANCREAS PORTAL CIRCULATION	SPLENIC CAPSULE DISEASE SPLENIC MALIGNANCY (MYELOGENOUS LEUKEMIA)
ETIOLOGICAL STUDIES: PORTAL HYPERTENSION ESOPHAGOGASTRIC VARICES UPPER GASTROINTESTINAL HEMORRHAGE UNEXPLAINED HEPATOSPLENOMEGALY OR UPPER ABDOMINAL DISEASE	CERTAIN SEVERE HEMORRHAGE STATES PRE-COMA OR COMA OF HEPATIC DISEASE
SURGICAL STUDIES: CHOICE OF SHUNTING OPERATION EVALUATION AFTER SHUNT	

CONCLUSIONS

A valuable test as a .....

RESEARCH TOOL TO

- STUDY PORTAL CIRCULATION
- SEARCH FOR HEMODYNAMIC AND ANATOMICAL SIGNS PREDISPOSING TO HEMORRHAGE FROM VARICES
- DECIDE THE ACTUAL VALUE OF SHUNTING OPERATIONS IN THE PREVENTION OF HEMORRHAGE FROM VARICES

CLINICAL TOOL IN

- DIAGNOSIS
- SURGICAL DECISIONS
- EVALUATING FUNCTION OF PREVIOUS SHUNTS

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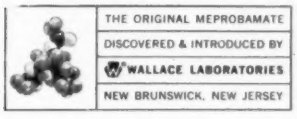

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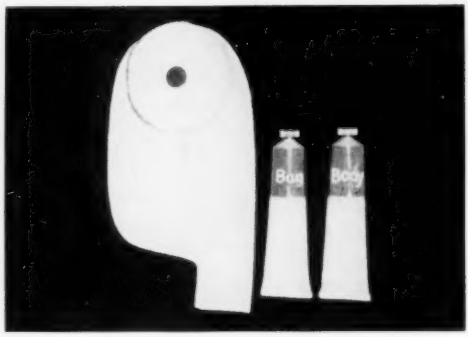

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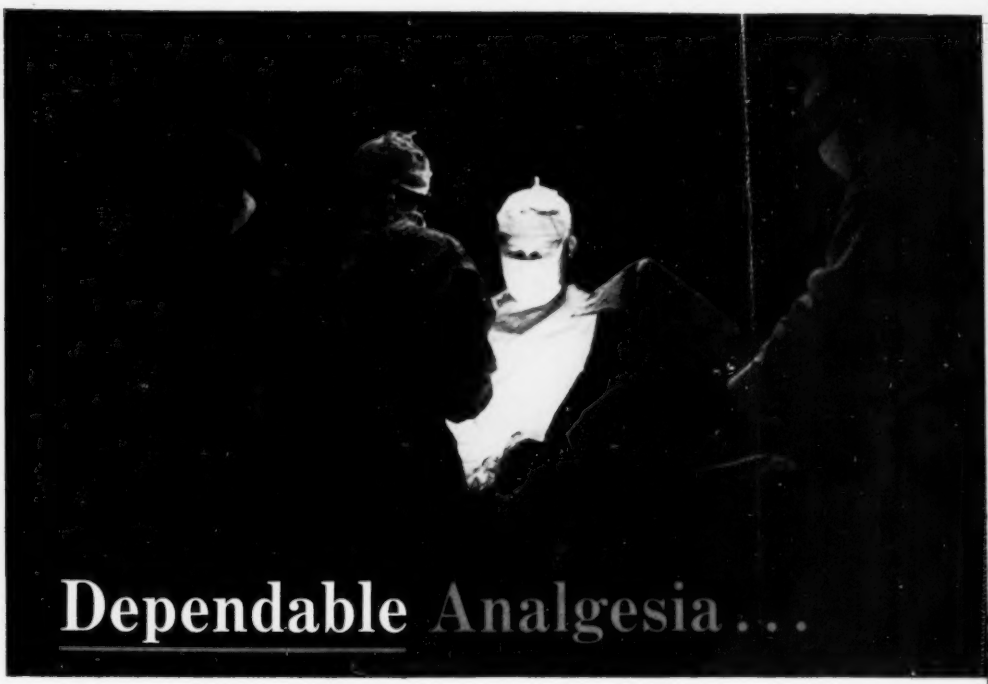

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